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VOLUME X NUMBER 1

REPORTS ON THE SCUTELLEROIDEA *and* THE ORTHOPTERA AND DERMAPTERA *of the Barbados-Antigua Expedition of 1918*

SCUTELLEROIDEA OF THE DOUGLAS LAKE REGION

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UNIVERSITY OF IOWA STUDIES
IN NATURAL HISTORY

PROFESSOR CHARLES CLEVELAND NUTTING, M. A., Editor

VOLUME X | NUMBER 1

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SCUTELLEROIDEA OF THE DOUGLAS LAKE REGION

Report on the Scutelleroiaea — DAYTON STONER

Report on the Orthoptera and Dermaptera — A. N. CAUDELL

The Scutelleroidea of the Douglas Lake Region — DAYTON STONER

PUBLISHED BY THE UNIVERSITY, IOWA CITY

REPORT ON THE SCUTELLEROIDEA

Collected by the Barbados-Antigua Expedition
from the University of Iowa in 1918

DAYTON STONER
Assistant Professor of Zoology, University of Iowa

INTRODUCTION

The material which serves as the basis for the present paper was secured mainly by the writer and Mrs. Stoner who were members of the scientific party from the University of Iowa which visited some of the West India Islands, Barbados and Antigua, in particular, during the spring and summer of 1918. Collecting was done on Barbados at irregular intervals and as time afforded from other duties between May 16 and June 11, and at Antigua between June 19 and July 19.

To the best of the writer's knowledge no systematic collecting of this group of insects has heretofore been indulged in on either Barbados or Antigua, although extensive general collecting has been undertaken on these as well as on certain other islands of the West Indies, namely Trinidad, Jamaica, St. Vincent and Grenada. Indeed, considerable intensive collecting has been done in some of these places. Of course various species have been reported from time to time on different islands of the group and on some islands certain species are of considerable economic importance.

At Barbados, only members of the family Pentatomidæ were secured, but, without doubt, representatives of the families Cydnidæ and Scutelleridæ also occur on the islands. Fortunately we were able to take two species of Scutelleridæ at Antigua, but representatives of the Cydnidæ were not discovered.

Most of the pentatomids here discussed have been hitherto recorded from the "West Indies" and some more specifically from Grenada and St. Vincent, but few from either Barbados or Antigua. Several of the present records are, therefore, new and all will either supplement or aid in the verification of the distributional data of the species concerned.

Keys for the identification of the species are not given, for it is probable that additional forms should be included in the fauna of the islands, and a key without embracing all the species would scarcely be justifiable. However, not much difficulty should be encountered in the determination of the forms discussed here, for in the case of the more obscure ones the brief diagnosis appended should be sufficient for ready delimitation.

The collection of pentatomids consists of approximately eight hundred pinned specimens, of which about one-fifth are *Edessa meditabunda.* In addition, many duplicates of the seven commonest species were taken. In all, seventeen species are represented in the lot. Nine of the seventeen were taken on Barbados and all the forms found on that island were also discovered at Antigua. Seventeen species are here recorded for the latter island.

Of the nine species taken at Barbados seven occur in the United States north of Mexico. The other two are exclusively Neotropical. Of the seventeen Antigua species fourteen occur also in the United States and three are strictly Neotropical.

By way of indicating something of the relative abundance, the following table showing the number of specimens taken of the eight least common forms, irrespective of the island upon which they were found, is appended.

Podisus fuscescens	1	specimen
Podisus sagitta	3	specimens
Sphyrocoris obliquus	3	”
Arvelius albopunctatus	13	”
Berecynthus delirator	15	”
Thyanta casta	19	”
Thyanta antiguensis	24	”
Vulsirea violacea var. *nigrorubra*	64	”

Each of the remaining nine forms is represented by a greater number of specimens than the last above mentioned.

It will be seen that the collection comprises a great number of borderline species, that is, forms which are commonly found between temperate and equatorial America. As a whole, the pentatomid fauna of the two islands seems to be Central American and Mexican in its affinities rather than South American.

A number of host and food plants of several of the species of pentatomids herein mentioned were preserved and brought back to the States for determination. However, through no fault of the writer, the package containing these plants was unfortunately lost so that this phase of the work must of necessity, be slighted.

The writer is indebted to Dr. L. O. Howard and to Mr. W. L. McAtee for the privilege of having access to specimens of Scutelleroidea in the United States National Museum, where Uhler's and other collectors' West Indian material is housed, and with which many of the specimens in the present collection were compared. Acknowledgement is also herewith tendered these men and other officials of the Museum who made available the use of a desk in the building during a part of the summer of 1921, when a number of comparative studies were made.

The following brief discussion concerning certain topographic, climatic and other conditions existing on Barbados and Antigua is quoted from a previous general account by the writer which dealt with some terrestrial arthropods occurring on these islands.[1]

"The island of Barbados is situated in 13° 4′ North latitude and 59° 37′ West longitude, and is the most easterly of the Antillean chain. It is about twenty-one miles long by fourteen broad, with an area of 166 square miles and a population of about 200,000, nine-tenths of which is black. The strata forming the basement series of Barbados consist of siliceous and calcareous sandstones and clays. About six-sevenths of the total area of the island is covered by a cap of coral rock which is more or less flat, and rises in a series of terraces to Mt. Hillaby in the "Scotland district," which is 1,104 feet in height. An area of approximately 6,000 acres at the northern and eastern side of the island has received that name on account of its peaked and hilly character. The remainder of the island is low and flat or, at most, slightly rolling, with few swamps and marshes and but two or three fresh water streams of any im-

1. Canadian Entomologist, Vol. LI, No. 7, 1919, 173-178 and Vol. LI, No. 8, 1919, 217-220.

portance. Practically all the tillable land is under sugar cane, and but few remnants of the forests which once covered the island now remain. The annual rainfall is about sixty inches, and usually comes in the form of showers during the summer months. The dry season occurs in the winter and early spring months.

"On account of the slight physiographic differentiation, the almost uniform state of cultivation and the density of the population, Barbados is not a particularly favorable place for collecting insects. In addition, practically all the grass land is closely grazed by goats and cattle, so that dense growths of vegetation are much restricted. In general, the affinities of the insect fauna are with that of South America, but a number of North American and closely allied forms are to be found. A few indigenous forms also occur.

"The island of Antigua is situated in latitude 17° 6′ N., and is the principal island of the Leeward group, of which it is the political capital. It is roughly oval in outline, twenty-four miles long by about fifteen broad, with an area of 108 square miles and a population of about 36,000. The central part of the island is low and flat and the soil more or less clayey; the southern and southwestern parts, in the vicinity of English Harbor, where a large share of the collecting was done, are volcanic and mountainous and covered, in many places, with dense forests. The greatest elevation is about 1,500 feet. To the north and northeast the soil is composed of calcareous marls and coarse sandstones.

"Extended periods of drought often visit the island, and the average annual rainfall is a little less than fifty inches. As a result of the nature of the soil and the protracted dry periods, the uncultivated vegetation is largely of a xerophytic nature. However, the soil, where it can be worked at all, is fertile and retains well the small amount of moisture. Sugar is the principal industry, although corn, yams and pineapples are cultivated on a small scale.

"Antigua is not under so high a state of cultivation as is Barbados; neither is it so thickly populated as that island. Natural enemies of insects are not numerous. All these conditions make for a more abundant and varied insect fauna than we found at Barbados."

List of species collected on Barbados and Antigua:

Family **Scutelleridæ**

Diolcus irroratus	A.[1]
Sphyrocoris obliquus	A.

Family **Pentatomidæ**

Mecidea longula	A.
Mormidea ypsilon	B.[2] and A.
Solubea pugnax	A.
Euschistus crenator	B. and A.
Berecynthus delirator	A.
Thyanta perditor	B. and A.
Thyanta casta	B. and A.
Thyanta antiguensis	A.
Vulsirea violacea var. *nigrorubra*	A.
Nezara viridula	B. and A.
Piezodorus guildingi	B. and A.
Arvelius albopunctatus	B. and A.
Edessa meditabunda	B. and A.
Podisus sagitta	B. and A.
Podisus fuscescens	A.

ANNOTATED LIST OF THE SPECIES COLLECTED

Family **Scutelleridæ**

Diolcus irroratus (Fabricius)

Plate I, Figs. 1 and 2

1775. *Cimex irroratus* Fabricius, Syst. Ent., 699.

This was the first species of scutellerid taken by us on the islands, the only other being *Sphyrocoris obliquus*. Both species were captured at Antigua, the present form being much the commoner of the two, and is represented by a considerable series of specimens.

The point of greatest abundance was on the top of Monk's Hill about seven hundred feet above sea level. Here, on all sides, grass and other dense vegetation thickly covered the rapid-

A.[1]=Antigua.

B.[2]=Barbados.

ly crumbling walls of the ancient structures and fortifications on this historic spot, and a good series of both adults and nymphs in various stages of development was taken on June 24.

Again, on June 26 several specimens were taken at Blizard's Mill. This structure, as indicated by the legend on a stone slab above the doorway, was erected in 1758 by G. Blizard, and was once used for grinding sugar cane, the motive power being derived from the wind. Nothing now remains of the old windmill except for ruins of the stone foundation, and the place is grown up in weeds and grass affording both food and shelter for these as well as many other insects.

In former years, small plots on the hills northeast of the village of English Harbor had been under cultivation, but more recently they have been permitted to grow up in grass and weeds. In such areas collecting was good, and Heteroptera in particular were common. On the guinea grass, a common plant in such situations, the present form, in both adult and nymphal stages, was taken in some numbers on July 5 and 10.

The females are larger, on the average, than the males; but two or three of the latter form exceptions in that they are as large as the largest females. Both the large and small males are uniformly punctured with brown on a yellowish or yellowish green background; the brown patches and fascia are pronounced in all the females.

A number of specimens of this species collected in Porto Rico by Mr. August Busck are in the collections of the United States National Museum.

Sphyrocoris obliquus (Germar)

Plate I, Fig. 3

1839. *Pachycoris obliquus* Germar, Zeitschr. Ent., Vol. I, 94.

Of this form but three specimens were taken on the following dates and under the circumstances indicated: July 3, guinea grass near the village of English Harbor; July 5, abandoned and reverted field northeast of English Harbor; July 8, Falmouth.

I have also a specimen from St. Vincent and one from the island of Bequia, both in about the same latitude as Barbados, but approximately one hundred miles west of it. We did not find *S. obliquus* at Barbados, although Uhler recorded it from Grenada. In view of the foregoing records it seems likely that this form may have escaped us at Barbados. It can readily be told from the preceding form, for the ostiolar canal is bent forward at a right angle near the broadly expanded tip.

Family **Pentatomidæ**

Mecidea longula Stal

Plate I, Fig. 4

1854. *Mecidea longula* Stal, Œfv. Vet. Akad. Förh., Vol. xi, 233.

This peculiar, elongate linear pentatomid is represented by a goodly number of specimens from a few restricted localities on Antigua only. It seems to prefer more or less open grassy areas well exposed to the sunlight.

At Point Barclay on the morning of June 21 a number of specimens, both adults and nymphs in all stages of development, were taken on *Chloris radiata;* again at about four o'clock in the afternoon the same spot was visited, when adults and nymphs in all stages were to be found feeding upon this grass after the heat of the day. Indeed, I believe that I have never found any pentatomid in greater abundance in a limited area than this species on the occasion just mentioned. (See Plate II, Fig. 2) Adults and nymphs were still abundant on the Chloris on July 5, on which date also a single adult was taken at the light in our dining room by Mrs. Stoner. Our quarters were about one-half mile from the nearest point where specimens were secured by sweeping, so the insect no doubt was attracted by our lamps. On this date a few specimens were taken in uncultivated areas among the hills adjoining the village of English Harbor.

In the West Indies this species seems to have been recorded from St. Bartholomew Island only in about 18° N. latitude.

Mormidea ypsilon (Linnæus)

Plate I, Fig. 5

1758. *Cimex ypsilon* Linnæus, Syst. Nat. (X Ed.) 443.

Undoubtedly this form is more common in Barbados than our single record would indicate, but it seems that if it were present in any considerable numbers we should have taken a larger series of examples. A female only was taken in an open weedy place. This specimen differs only from the Antigua specimens in having shorter and blunter humeri.

More than fifty specimens are at hand from Antigua, taken mostly at Monk's Hill, June 24; at Golden Grove, in a low lying, swampy, uncultivated field near a quarry, June 26; very common in a solanaceous weed patch near Falmouth, July 1 and 8. None are of the form *inermis* Dallas, the pronotal angles in all being drawn out into acute spines. I have a specimen of the latter form taken by H. A. Ballou on St. Lucia, and also specimens of typical *ypsilon* from Nevis and St. Lucia. Several half-grown nymphs taken at Antigua during July are also in our collection.

Uhler records the species from Grenada.

Solubea pugnax (Fabricius)

Plate I, Fig. 6

1775. *Cimex pugnax* Fabricius, Syst. Ent., 704.

A large series of this species from Antigua only is at hand. It is one of the most abundant pentatomids on the island. Considerable difference in size between the sexes is apparent; the smallest male being but 9.0 mm. in length, the largest female 11.5 mm. long. I can see no appreciable difference between a series of specimens from Antigua and a series made up of individuals secured in different parts of the United States, except that the tropical series averages a little smaller, specimen for specimen. Dates and localities are as follows:

Golden Grove, June 26; low, uncultivated area near quarry. Falmouth, July 1; abundant in grassy places cleared of brush and along edges of cultivated fields.

Euschistus crenator (Fabricius)

Plate I, Fig. 7

1794. *Cimex crenator* Fabricius, Ent. Syst., Vol. IV, 101.

This common form, somewhat variable in depth of coloration and in acuteness of the humeri, was taken at both Barbados and Antigua. At Barbados it was found in some numbers in almost every place that collecting was done, particularly where the vegetation was partly shaded. In June, adults were much more abundant than nymphs.

E. crenator can scarcely be confused with any other pentatomid of the region. With its subacute humeri directed upward and slightly backward and the black, concavely arcuated, finely and rather regularly denticulated antero-lateral pronotal margins. Length 8.5-10.0 mm.

On the afternoon of July 1 at the foot of Monk's Hill, Antigua, not far from the little village of Falmouth, in a small, low, swamp-like area not more than sixty feet in diameter, but perfectly dry at this time, although well shaded by small trees, Mrs. Stoner discovered great numbers of this species on a thickly growing solanaceous plant. Some of the plants were literally overrun with the insects. After a few strokes of the hand net fifty-two adults, along with several nymphs, were taken from the bag. About a hundred specimens were taken and as many more could very easily have been secured. A few examples were also taken near this place from the grassy edges of small cultivated fields. On the morning of July 8 I again visited the patch of Solanaceæ with fair returns for my efforts, but what was my surprise, on again beating the same plants about four o'clock in the afternoon, to find the species as abundant as it was a few hours previously. A few *M. ypsilon* were also taken at the same time.

Northeast of English Harbor, in uncultivated areas formerly cultivated to cotton and other plants, but recently permitted to grow up in weeds and grass, the species was not uncommon on July 5.

Berecynthus delirator (Fabricius)

Plate I, Fig. 8

1787. *Cimex delirator* Fabricius, Mantissa Insect., Vol. II, 286.

Fourteen adult specimens of this species which is widely distributed in South and Central America and Mexico were taken at Antigua between July 1 and 15. The acutely pointed anterior extremity of the tylus is considerably produced beyond the anterior margin of the head, and the specimens show no tendency to vary in this regard, the nymphs also sharing in this character.

Localities and dates are as follows: Falmouth, July 1, 8 and

9; uncultivated areas in the hills northeast of English Harbor. On July 12, following a heavy rain, I again visited the uncultivated areas northeast of English Harbor, where, on the tall, coarse grass growing in the little gullies on the hillsides which had been much refreshed by the recent downpour, five adults and several nymphs of this form were taken.

Thyanta perditor (Fabricius)

Plate I, Fig. 9

1794. *Cimex perditor* Fabricius, Ent. Syst., Vol. IV, 102.

Our collection contains numerous examples from Barbados which were swept from succulent vegetation growing in low or more or less protected situations.

The specimens vary from dark green to testaceous with the sanguineous median line on tylus and interhumeral band well marked. Pronotal angles very acute and inclined sharply forward. Connexivum pale yellowish to fulvous alternated with black or green. Basal portion of membrane with a greater or less number of brownish or blackish dots.

About forty specimens were also taken at Antigua; more than one-third of these depart from the usual dark greenish coloration in that they are pale testaceous.

This is a widely distributed and, in some places, a common species occurring in most of the West India Islands and on the continent from northern Brazil to Georgia and Colorado.

Thyanta casta Stal

Plate I, Fig. 10

1862. *Thyanta casta* Stal, Stett. Ent. Zeit., Vol. XXIII, 104.

But two specimens were taken at Barbados. In these the punctuation is coarse, and the pronotum and hemelytra have a somewhat calloused appearance. There is a slender black line on the extreme edge of each pronotal angle. Length, 8.75 mm.

About twenty examples were taken by us at Antigua.

Uhler records this as the least common of the three species of the genus taken by him on Grenada.

Thyanta antiguensis (Westwood)

Plate I, Fig. 11

1837. *Pentatoma antiguensis* [Westwood], Cat. Hope, Vol. I, 36.
1851. *Pentatoma taeniola* Dallas, List Hem., Vol. I, 250.
1894. *Thyanta taeniola* Uhler, Proc. Zool. Soc. London, 173.

We have about twenty-five examples of this species from Antigua only, taken on June 11 and 21, and on July 1, 8 and 12. Seven of the specimens are of a distinctly testaceous tinge; all have the sanguineous band on the pronotum more or less apparent.

Vulsirea violacea var. *nigrorubra* Spinola

Plate I, Fig. 12

1837. *Vulsirea nigrorubra* Spinola, Ess. Hém., 351.
1843. *Vulsirea nigrorubra* Amyot and Servile, Hém., 143.

This most strikingly colored metallic blue and red species, of which more than fifty specimens, including nymphs in two different instars are at hand, was taken at Antigua only. The variation in coloration among this series of specimens is exceedingly pronounced, scarcely any two of the lot being marked exactly the same.

The first specimens of the species that came to my hands were secured by Prof. A. O. Thomas, the geologist of the expedition, from a spot about half way up the thickly wooded side of Monk's Hill at an elevation of about four hundred feet, June 22. On June 24 I took about twenty specimens, among them a few nymphs, from a slender, willow-like tree which, as proved later to be the case, was the same one from which the former specimens had been secured. I also took one specimen at the old fort on the summit of Monk's Hill on the same date. On July 1 two nymphs and two adults were seen on the tree visited on June 22. But one of the adults were taken, the remainder being left in the hope that their progeny might serve to augment other collections.

In the National Museum collections there repose specimens from Florida, Cuba and Trinidad. The latter is a nymph two-thirds grown.

Nezara viridula (Linnæus)

Plate I, Fig. 14

1758. *Cimex viridulus* Linnæus. Syst. Nat. (X Ed.) 444.

It was no surprise to find this cosmopolite among the Scutelleroidea on both the islands visited, and on Barbados it was surpassed in abundance only by *Edessa meditabunda.*

The shores along the west coast of this island rise in a series of terraces, each of which extends inland for approximately a half mile. Along the sides of these more or less precipitous slopes the vegetation often grows in considerable profusion for, when the rains come, the moisture is not evaporated so quickly as in the open. In addition to the present species, several other pentatomids and many kinds of plant-feeding bugs here find habitats suitable to their needs. *N. viridula* was also found on weeds and various kinds of herbage growing in other protected places, for example the sides of the terraces on the Hawkins Estate. Collecting dates: May 16, 22, 28, 29 and June 3 and 6.

Recent studies of this bug have shown that in both nymphal and adult stages it is a carrier and distributor of an internal fungous disease of the cotton boll on Barbados and neighboring islands, and it has, on this account, attracted considerable attention and study.*

This species was not by any means so abundant at Antigua and but ten specimens represent our efforts during the months spent there. Most of these were taken from grass growing in an open, swampy field near Golden Grove, June 26.

Piezodorus guildingi (Westwood)

Plate I, Fig. 13

1837. *Raphigaster Guildinii* [Westwood] Cat. Hope, Vol. I, 31.

A moderately common pentatomid in most places where we collected on both islands. It is a trimly built and very active species somewhat variable as to size, convexity and coloration. Fully colored adults are of a clear green with a narrow, reddish impunctate, or sparsely punctate band across the pronotum. Length, 8.0-10.0 mm.

The best collecting ground on Barbados was in the vicinity

* Nowell, William, West Indian Bulletin, Vol. XVI, No. 3, 1917, 203-235.

of the Hawkins Estate where both nymphs and adults were taken on several occasions during June.

Localities and collecting dates for Antigua are as follows: Monk's Hill, one specimen, June 24; Golden Grove, low-lying, uncultivated field, June 26; Falmouth, July 1; vicinity English Harbor, July 12.

The species was first described from the island of St. Vincent.

Arvelius albopunctatus (deGeer)

Plate I, Fig. 15

1773. *Cimex albopunctatus* deGeer, Mém., Vol. III, 331, Pl. 34, fig. 6.

From Barbados I have two adult males, four females and several nymphs in the third instar, all taken on the Hawkins Estate from a species of Solanum, which is common along the bluffs where some moisture is retained by the trees and vegetation. (See Plate II, Fig. 1) It appears to be an uncommon species on the island and is not found out in the dry, sun-baked fields. But two specimens, a male and a female, were taken at Antigua. I am indebted to Dr. J. C. Hutson of the Imperial Department of Agriculture for two additional specimens taken on the island of St. Vincent in November and December.

In life, the general color above is bright green, with a narrow transverse band across the anterior third of the pronotum light yellow; this color extends out over the basal portion of the humeral spines, which are tipped with green. There are a few white calloused spots on the hemelytra, scutellum and basal one-half of the pronotum, among which are sparsely placed minute black dots. My specimens show little tendency to vary in these respects. Unfortunately, the color fades on drying, when the insect assumes a yellowish green appearance, the black dots, somewhat variable in abundance, standing out rather conspicuously thereon.

This form is widely distributed in the Neotropical region, occurring from Southern United States south through Mexico and several South American states into Argentine. It is also recorded from Cuba, Haiti, Jamaica, Grenada, St. Vincent and Trinidad.

Edessa meditabunda (Fabricius)

Plate I, Fig. 16

1794. *Cimex meditabundus* Fabricius, Ent. Syst., Vol. IV, 113.
1894. *Edessa rugulosa* Uhler, Proc. Zool. Soc. London, 177.

This is the most common pentatomid on Barbados and was taken in considerable numbers on every trip. It is commonly called "Pea Chink" by the native Barbadians who, being more or less familiar with its odoriferous qualities, and upon seeing us take the bugs, frequently inquired if we intended to make medicine of them. Apparently the ill taste of certain medicines with which they were familiar was associated with the ill smell of the bugs.

On May 20 a few examples were taken from the bare hills in St. Michael's Parish, about five miles from Bridgetown. The region is very rough with some bushes, low trees and grass, but the place is so thickly populated and so closely grazed by goats and cattle that the vegetation is not profuse and plant feeding insects are not numerous.

North of Bridgetown on and near the Hawkins Estate, along sheltered terraces where rapid evaporation of the rather meager amount of precipitation is prevented, the vegetation is more profuse and this species was found abundantly in this and similar situations. In low places and small ditches grown up in vegetation over which the water flows in torrents during the rains *E. meditabunda* and many other plant-feeding insects find a plentiful supply of food. The former seemed to be especially fond of a solanaceous plant of some sort and on May 28 in six sweeps of the hand net fourteen adults and one nymph of this species were taken. Again, a little farther on, in a half dozen sweeps of the net, thirteen adults were captured.

A few examples were taken in the vicinity of Christ Church, Oistin Bay.

A deep gully along the railroad tracks about two miles out of Bridgetown, in spite of the fact that it is kept closely pastured by goats and cattle, supports an abundant vegetation. Here, on the afternoon of June 3, we took considerable numbers of the present species as well as examples of most other pentatomid species which occur on the island.

At Antigua, the species was much less common, although a goodly number of specimens are at hand from Monk's Hill, Falmouth and vicinity.

The bug is recorded from most of the West India Islands and it also enjoys a wide distrubution in South America.

Podisus sagitta (Fabricius)

Plate I, Fig. 17

1794. *Cimex sagitta* Fabricius, Ent. Syst., Vol. IV, 99.

But a single specimen, a male collected along a protected terrace on the Hawkins Estate, came to our hands in Barbados.

In an uncultivated area northeast of the village of English Harbor, Antigua, two specimens were taken. These are our only records.

In appearance, this form resembles our northern *P. maculiventris,* but the humeri are somewhat emarginate behind and turned upward and forward a little more than in that species.

P. Sagitta has been recorded from the Amazon northward through Mexico and in Texas,, as well as generally throughout the West Indies.

Podisus fuscescens (Dallas)

1851. *Arma fuscescens* Dallas, List. Hém., Vol. I, 102.

Bue one specimen of this fine species was taken; it is a female. collected by Prof. A. O. Thomas at Half Moon Bay, six miles east and a little north of English Harbor, Antigua.

There are specimens in the United States National Museum from Costa Rica. The type specimen was taken in Mexico.

PLATES

PLATE I

Fig. 1. *Diolcus irroratus,* female
2. *Diolcus irroratus,* male
3. *Sphyrocoris obliquus*
4. *Mecidea longula*
5. *Mormidea ypsilon*
6. *Solubea pugnax*
7. *Euschistus crenator*
8. *Berecynthus delirator*
9. *Thyanta perditor*
10. *Thyanta casta*
11. *Thyanta antiguensis*
12. *Vulsirea violacea* var. *nigrorubra*
13. *Piezodorus guildingi*
14. *Nezara viridula*
15. *Arvelius albopunctatus*
16. *Edessa meditabunda*
17. *Podisus sagitta*

PLATE I

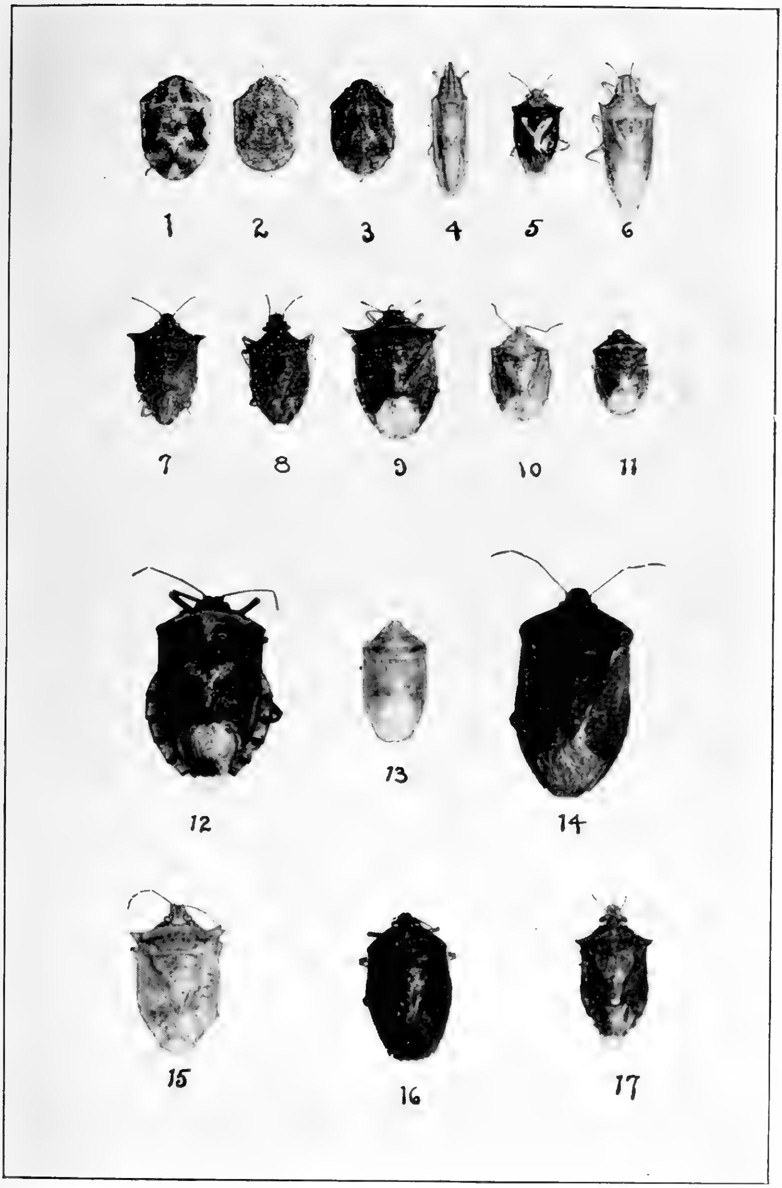

PLATE II

Fig. 1. Collecting pentatomids along protected terrace, Hawkins Estate, Barbados, B. W. I.

2. Habitat of *Mecidea longula,* old powder house in center, Point Barclay, Antigua, B. W. I.

PLATE II

Figure 1

Figure 2

PLATE III

Fig. 1. Collecting grounds showing xerophytic conditions near English Harbor, Antigua, B. W. I.

2. High grassy collecting ground overlooking English Harbor, Antigua, B. W. I.

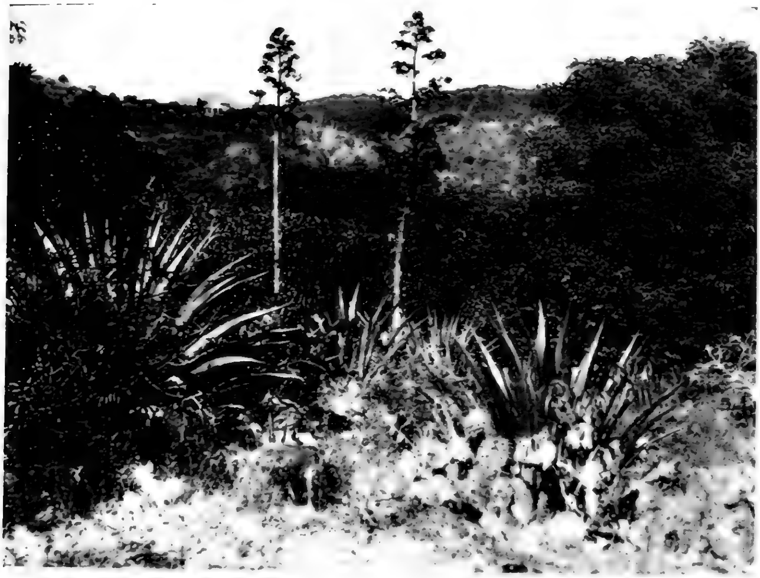

Figure 1

Figure 2

REPORT ON ORTHOPTERA AND DERMAPTERA

Collected by the Barbados-Antigua Expedition
from the University of Iowa in 1918

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The orthopterous and dermapterous insects taken on the above expedition, sent out by the University of Iowa, were mostly collected by Prof. Dayton Stoner, who submitted them to the writer for determination and report. At first glance the collection did not appear promising, but upon more thorough examination it proved unexpectedly interesting, as will develop, the writer hopes, in the following report. Not only are there several apparently undescribed forms represented, but certain facts of geographical distribution, morphological variation, etc., have been brought out by the studies made.

By previous arrangement the material here reported upon is divided between the collection of the U. S. National Museum and that of the University of Iowa, uniques, where desired, and types of new species going to the former collection.

In the following pages the original references are quoted and also references to Kirby's *Synonymical Catalogue of Orthoptera,* published by the British Museum, where one interested may find other pertinent references. Additional references are sometimes given and the more important synonyms are enterd, with the original reference to each.

The entire collection as submitted to the writer consisted of 334 specimens comprising 31 species, distributed in the various families as follows:

Family	*No. of species*	*No. of specimens*
Forficulidæ	2	16
Blattidæ	8	50

Mantidæ	2	20
Phasmidæ	2	27
Acrididæ	7	149
Tettigonidæ	3	34
Gryllidæ	7	38
	31	334

DERMAPTERA

Family **Forficulidæ**

(The earwigs)

Genus Anisolabis Fieber

Anisolabis minuta Caudell

Anisobalis minuta Caud., Journ. N. Y. Ent. Soc., vol. xv, p. 168 (1907).

Borellia minuta Burr. Proc. U. S. Nat. Mus., vol. xxxviii, p. 448, 465 (1910).

Euborellia minuta Burr. Trans. Ent. Soc. Lond., p. 180, foot-note (1910).

Euborellia minuta Rehn and Hebard, Bull. Amer. Mus. Nat. Hist., vol. xxxvii, p. 639 (1917).

Two males and four females of this small earwig were taken; one male and two females on Antigua in June and one male and two females on Barbados in May.

This species, together with the following one, as well as certain other allied forms, are by many recent writers placed in the genus *Euborellia* of Burr. This genus, however, as now characterized, rests wholly on internal characters of the male. As such characters are deemed by the writer as wholly unsuited for generic differentiation, this genus is not accepted.

Anisolabis ambigua Borelli

Anisolabis ambigua Borelli, Boll. Mus. Torino, vol. xxi, No. 531, p. 3 (1906).

Borellia ambigua Burr. Deutsch. Ent. Zeitschr., p. 325 (1909).

Euborellia ambigua Burr, Trans. Ent. Soc. Lond., p. 180, pl. xlvi, fig. 7 (1910).

Euborellia ambigua Rehn and Hebard, Bull. Amer. Mus. Nat. Hist., vol. xxxvii, p. 638 (1917).

Ten specimens of this species were taken, two males and eight females, all from Barbados in May, except one female from Antigua in June. The male from Barbados is immature.

This insect superficially very much resembles the former species, *A. minuta,* but inspection will show *minuta* to have some antennal segments pale, the small tegmina well separated and the femora ringed with black, while in *ambigua* the antennæ are unicolorous, the tegmina overlapping and the femora more broadly blackish, less distinctly ringed.

Two other species of *Anisolabis, A. maritima* Linn., and *A. annulipes* Lucas, are found in the West Indies, but none appear to have been taken on this expedition.

ORTHOPTERA

Family **Blattidæ**

(The cockroaches)

Genus Blattella Caudell

Blattella germanica Linnæus

Blatta germanica Linn., Syst. Nat. ed., 12, p. 668 (1767).
Phyllodromia germanica Kirby, Syn. Cat. Orth., vol. I, p. 87 (1904).
Blatella germanica Caudell, Proc. Ent. Soc. Wash., vol. v. p. 234 (1903).
Blatta bivittata Serv., Ins. Orth., p. 108, (1839).
Blatella bivittata Caudell, Journ. N. Y. Ent. Soc., vol. XII, p. 183 (1904).
Blattella bivittata Hebard, Mem. Amer. Ent. Soc., No. 2, p. 57 (1917).

A single specimen, a male, of this cosmopolitan house roach was taken on Barbados on May 16. No notes accompany the specimen, but it may be safely assumed that it was taken indoors.

Genus Symploce Hebard

Symploce capitata Saussure

Blatta capitata Sauss., Rev. Mag. Sool. (2), vol. XIV. p. 167 (1862).
Ischnoptera capitata Kirby, Syn. Cat. Orth., vol. I, p. 82 (1904).

Two female specimens of this roach are in the collection, both from Antigua and are very surely among the ones referred to in a manuscript note by Prof. Stoner as finding a safe and cool retreat among small epiphytes, resembling small pineapples, growing on trees in a wooded portion of Monk's Hill. This note is quoted at the end of the Blattidæ.

Genus Periplaneta Burmeister

Periplaneta americana Linnæus

Blatta americana Linn., Syst. Nat., ed 10, p. 424 (1758).
Periplaneta americana Kirby, Syn. Cat. Orth., vol. I, p. 140 (1904).

Represented by a single specimen, a male from Barbados, taken in June. The species noted under this name by Prof. Stoner in Canadian Entomologist, vol. LI, p. 217 (1919) were, at least for the most part, the *P. brunnea* listed below.

Periplaneta australasiae Fabricius

Blatta australasiae Fabr., Syst. Ent., p. 271 (1775).
Periplaneta australasiaes Kirby, Syn. Cat. Orth., vol. I, p. 141 (1904.)

One male and two females were taken by Prof. Stoner on Barbados, one being labelled "Pelican Island."

Periplaneta brunnea Burmeister

Periplaneta brunnea Burm., Handb. Ent., vol. II, p. 503 (1838).
Periplaneta brunnea Kirby, Syn. Cat. Orth., vol. I, p. 142 (1904).
Periplaneta truncata Krauss, Zool. Anz., vol. XV, p. 165 (1892).

This large brown roach is represented by three adult, one male and two female, and three immature specimens all taken on Barbados, the male and the nymphs on Pelican Island.

Hebard, Mem. Amer. Ent. Soc., No. 2, p. 178-188 (1917), treats the above species of *Periplaneta* very fully, and on pages 14 and 20 of the same publication keys for their separation will be found.

Genus EURYCOTIS Stal

Eurycotis similis n. sp.

Specimens representing both sexes of a roach referable to the genus *Eurycotis* were taken on Antigua, which, while apparently related to certain variegated forms of that genus, as the *decipiens* of Kirby, do not agree sufficiently well with any described species, either of *Eurycotis* or the closely allied *Pelmatosilpha,* to be considered identical with any of them. This species is accordingly here characterized as new.

Description.—Size medium for the genus. Head not quite hidden beneath the pronotum; color yellow with three transverse black bands of various widths, one vertical, one betwen the antennæ and one between the last and the base of the clypeus, the last often somewhat narrower than the others, the vertical and interantennal bands rarely more or less interrupted mesially, the lower bar turning up laterally along a deep lateral facial fold to almost meet the lower edge of the eyes; eyes ashy gray, narrow, reniform, separated by a space a little broader than that between th antennal scrobes; ocelli obscure, subcutaneous; antennæ much longer than the body, uniformly dark reddish brown.

Pronotum truncate posteriorly, where it is somewhat broader than the length; color bright yellow with a very narrow piceous margin all around, broader posteriorly and with a conspiculus crescent-shaped black area on the anterior two-thirds which reaches the anterior margin of the disk; meso- and metanotum yellow. Organs of flight abbreviated as in all species of the genus; tegmina subquadrate, just barely longer than the pronotum and overlapping somewhat when closed, the apical margin truncate with rounded angles; color yellow with the anal margin a little infuscated, that of the right one with a very distinct longitudinal submarginal stripe limiting that portion covered by the left tegmina when closed; wings shorter than the tegmina, folded once longitudinally when at rest.

Legs short and moderately stout; trochanters, coxæ and femora mostly yellowish or yellowish brown, the femora with dark spines and the trochanters lined basally with black; anterior and intermediate tibiæ and tarsi yellowish brown, the posterior ones darker, all with blackish spines; all femora armed beneath on both margins with several stout spines, the anterior ones with 8 to 11 and two longer apical ones on the anterior margin and four on the posterior margin; tarsi with conspicuous, usually light colored, pulvulii and with very large and thick apically truncate arolia.

Abdomen heavy, black in color, with the basal five or six segments marked above and below with a small lateral yellow spot and the basal dorsal segment partly yellowish on the basal half or more; supraanal plate fully twice as long as broad in the male, less than twice as long as broad in the female, the posterior margin broadly notched, more roundly so in the female; subgenital plate of the male about four times as broad as long, the basal width being about equal to the apical width of the preceding segment of the abdomen; apical margin almost straight, notched at each side at the point or origin of a pair of strong apical styles, which are gradually pointed and about five times as long as the basal width; subgenital plate of the female with the valves occupying over one-half their length and terminating at a deep transverse incision, the valvular area very distinct from the broad basal portion by reason of the lateral margins of the valvular portion being turned under so as to almost meet, forming a chitinized triangular funnel, the inner side of which is divided by two submesial longitudinal membraneous partitions, the base of the channel thus formed having a covering of very fine yellow hair of considerable length on the surface formed by the plate, and some similar but shorter hairs outside this channel on the undersurface of the plate itself, and the entire surface, the outer walls of the membraneous channel and all, with numerous short and very small, but sharply pointed, tubercles.

Cerci broad and short, but moderately surpassing the supraanal plate, especially in the female, and consisting of about ten segments, all of which are transverse except the apical one which is slightly elongate and sharply pointed.

Concealed genital organs: The genital chamber[1] of the male has what appears to be a rather complete and fully chitinized armature, consisting of various plates, spines and projections. The sinistral hook, fig. 1, a, is a

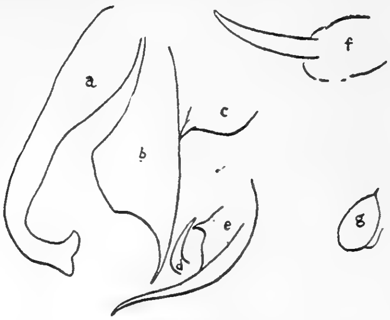

Figure 1

rather slender projection with the basal half broadly flattened vertically, thence but slightly flattened and gradually tapered to a more flattened, apically incurved and briefly furcate tip; this hook very likely projects somewhat, the tip not being wholly concealed within the chamber. Partly overlying the sinistral hook basally is a laterally broadly flattened projection, gently twisted inwards, the outer surface convex and the inner surface concave and the upper apical margin prolonged and narrowed to form a sharp, slender spine extending to about the apex of the sinistral hook; this organ is illustrated at Fig. 1b. To the right of the last noted organ, and at about the middle of its length, is a thick subquadrate apically

1. The taxonomic importance of the concealed genital organs of roaches, especially of the males, is becoming more appreciated, and the use of such characters has been encouraged by the recent studies of Mr. Hebard, who has introduced a few special terms for certain of these organs. The three following are now in use, and their significance is as follows:

Genital chamber. The space between the subgenital and supraanal plates in which are contained the concealed genital organs. By cutting transversely along the base of the subgenital plate with a sharp scalpel or fine pointed scissors, that plate may be, in fresh or alcoholic speciments, laid over sideways, preferably to the right, or the left as the roach lies on the back; the incision at the base of the plate is not made quite across the entire width, thus leaving a small portion to act as a hinge when it is laid over.

Sinistral genital hook. A more or less slender, often incurved, organ projecting more or less conspicuously on the left side of the genital chamber of the male, usually wholly concealed before the subgenital plate is laid over, but sometimes projecting somewhat beyond that plate. There is much variation in the shape of this hook, as will be seen by the figure 1 of the present report and figures on plate ix of Hebard's work on the United States Blattidæ in Mem. Amer. Ent. Soc., No. 2.

Dextral genital hook. A usually more or less thickened broad plate lying in the right side of the genital chamber of the male, also variable in shape. Illustrations of those of *Arenivaga* sps. will be found on the above mentioned plate by Hebard.

Some roaches, the new *Eurycotis* here described being a good example, have various other very remarkable chitinized spines, spurs, plates, etc., and eventually a number of various terms will be necessary for their proper designation. More extensive com-chitinized piece with the left hand apical part forming a short, sharp, apically slightly decurved tooth, Fig. 1c. Below this last described piece, projecting from a fleshy base, is a sharp upwardly directed chitinized spine, Fig. 1d, and to its right lies a large basally folded plate, fully chitinized, and with the rgiht portion developed into a very long, sharp and slender sinuate spine, directed caudad and to the left, and extending out fully as far as the tip of the sinistral hook; Fig. 1e shows this structure, and illustrates, as well as may be, how the chitinized base forms on the left a blunt tooth-like projection, but does not show the deep transverse folding. Far back in the right hand side of the chamber is seen a long, slender, recurved, fully chitinized, cycle-like blade curving to the left near the dorsal wall of the chamber and apparently arising from a fleshy unchitinized base of considerable size; this is the dextral hook and is shown at Fig. 1f. Below the base of the above noted appendage there is a large, thick, apically truncate, partly chitinized mass, as roughly indicated from an apical view at Fig. 1g. The unchitinized or partly chitinized portions of the genitalia, as noted above, may be noticeably different in fresh specimens, but the chitinized portions, so far as visible and here described, will probably prove stable, though more of them may possibly be found if fresh or alcoholic material be more thoroughly dissected, as they may lie wholly concealed by tissue.

In the genital chamber of the female we see the six valves of the ovipositor grouped about the middle of the chamber, and on either side of the ovipositor is a thin, horizontal, bluntly subtriangular plate with the surface sparsely covered with coarse short bristly spinules; above the back of these plates and extending to the base of the ovipositor are thick chitinized areas of definite shape.

Measurements.—Length, entire insect from front of head to tip of supraanal plate, ♂, 29 mm., ♀, 25 to 29 mm.; pronotum, ♂ 8 to 9 mm.; tegmina, ♂ and ♀, 9 mm.; width, pronotum at hind margin, ♂ 11 mm., ♀ 11 to 12 mm.; tegmina at middle, ♂ 8 to 9 mm.

Type ♂, Antigua, June 29, 1918; allotype, ♀, same data as the type; paratypes a, b, and c, adult ♀♀, a and b same data as types and c dated July, and d, e and f, ♂ nymphs, same data as type.

Type, allotype and paratypes c and d in collection of the United States National Museum, the rest of the material in the University of Iowa.

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parative studies of different genera and groups is desirable, however, before attempting to formulate a satisfactory terminology.

The genital chamber of the female, so far as now known to the writer, contains no such complicated structures as found in the males. In the chamber of the female is found a rudimentary ovipositor consisting of six grouped valves, short and not, or but little chitinized, extending out from the posterior portion of the cavity and there may be on each side of this ovipositor a broad partly chitinized plate. On the inner surface of the subgenital plate, and thus in the genital chamber, there may be a channel formed by longitudinal partitions, as described herein under *Eurycotis similis*. But in no species examined have I found chitinized organs corresponding to the genital hooks and other fully chitinized structures of the male.

Genus Pycnoscelus Scudder

Pycnoscelus surinamensis Linnæus

Blatta surinamensis Linn., Syst. Natur., ed. XII, p. 687 (1767).
Leucophaea surinamensis Kirby, Syn. Cat. Orth., vol. I, p. 151 (1904).
Pycnoscelus surinamensis Hebard, Mem. Amer. Ent. Soc., No. 2, p. 193, pl. VIII, fig. 1 (1917).

This cosmopolitan roach, which has a number of synonyms recorded in literature, is represented in this collection by thirteen specimens, six adults and seven nymphs of various sizes, all females. Two of the adults are from Antigua, the others from Barbados.

This species, the males of which are extremely rare, has been recorded from various of the West Indian Islands and is a roach quite generally met with throughout the warmer regions of the world.

Genus Hemiblabera Saussure

Hemiblabera granulata Saussure

Hemiblabera granulata Sauss., Soc. Ent., vol. VII, p. 68 (1893).
Hemiblabera granulata Kirby, Syn. Cat. Orth., vol. I, p. 166 (1904).
Hemiblabera granulata Sauss. and Zehnt., Biol. Cent. Amer., Orth., vol. I, p. 122, plate V. fig. 21 (1894).

Sixteen specimens of a roach which I refer to this species were taken by the expedition, four adult and two immature males and nine adult and one immature females, all from Antigua on the 24 and 29 of June.

The above specimens agree too well with the description of *granulata* to allow of their being considered other than that species, in spite of their occurrence so far from the type locality, which is given in the original diagnosis as merely "Mexico." But in the following year, Biol. Cent. Amer., Orth., vol. I, p. 122, the more exact locality "La Antigua in Vera Cruz" is given. The type is said to be in the Geneva Museum, but how many specimens there were is not recorded.

The male of this species appears to be as yet undescribed. This sex may be easily distinguished from the female, not by the number of abdominal segments, which appear to be the same in both sexes, but by the generally, but not invariably, smaller size of the male and by the subgenital plate, which is in the female almost as broad basally as the apical width of the preceding segment while in the male it is but little more than one-half as broad. In the male there is also a small slender apical style on each side of the subgenital plate near the circus; in the female there are no such styles. There are other external differences and the concealed genital structure differ greatly.

In the genital chamber of the male there are a number of chitinized or partly chitinized structures, the most conspicuous of which are the following: On the right hand side of the chamber, and situated high up near the supraanal plate is a yellow subchitinized organ shaped as in fig. 2, the pointed end directed

Figure 2

to the left and upwards, the basal portion roughly subtriangular in section and the curved horn-like extremity subcylindrical; anterior of the above noted organ and slightly nearer the median line, and so far back as to arise almost beneath the preceeding ventral segment of the abdomen and easily escaping notice if but casually examined, is a piceous, fully chitinized, upwardly and outwardly curved object, laterally somewhat flattened, the apex bifurcate, each branch flattened and apically rounded, the lower one about one-half as long as the upper one. In the center of the chamber is an unchitinized rounded flap apically bearing several stout, acutely triangular and laterally flattened teeth, and above it, lying between it and the dorsal wall, is a black chitinized organ consisting of a sort of obtuse V-shaped piece, the closed end directed caudad, the left arm very broad and so closely attached to the fleshy flap beneath it as to appear but a narrow strip unless elevated especially for examination; the right arm is apically free, forming a rounded, slightly recurved club-shaped appendage. In the left side of the chamber, and well back, is an apically rounded, slightly chitinized flap, the basal portions, so deeply embedded in tissue as to be difficultly seen, showing some more fully chitinized margins and may terminate further back in a long spine, or other appendage, though no such is to be seen in moderate dissections. The thickened and chitinized upper margins of the chamber and the inner apical margin of the subgenital plate bear bristly hairs. No attempt is here made to suggest homologies for the male genitalia as above described.

In the female we find in the genital chamber but a single noticeable organ, which is the rudimentary ovipositor consisting of six short, unchitinized appendages grouped compactly and attached near the upper wall in the middle of the chamber; these ovipositor valves are probably naturally directed caudad, but in several specimens, in which fully formed but unoxydized ootheca filled the cavity, they are directed diagonally backwards towards the head, or cephalad; the valves are finger-like and somewhat foot-shaped apically, at least one pair, the lower and largest ones, the others being somewhat shorter and more evenly rounded apically. Hebard, Mem. Amer. Ent. Soc., No. 2, p. 284, plate x, fig. 16 (1917), calls this the concealed ovipositor; it is somewhat remindful of the external, but abortive, ovipositor in *Stenopelmatus* and *Anurogryllus.* If these valves are directly concerned with oviposition, the eggs must be immediately arranged in the simultaneously forming ootheca, which is, at least in the females of the present species containing them, extended back into the abdominal cavity as successive lots of eggs are added, the completed ootheca almost completely filling the body cavity, the end near the tip of the abdomen only in juxtaposition with the ovipositor. This seems to show that the ootheca is formed completely within the body before it commences to be ejected, and that the end first appearing when deposited is the one last formed, just the opposite of what the writer had supposed the facts to really be.

The range of measurements represented in the material of the roach now under consideration is as follows: Total length, front of head to tip of supraanal plate, ♂, 28 to 32 mm., ♀, 31 to 37.5 mm.; tegmina, ♂, 6.5 to 8 mm., ♀, 7 to 8 mm.; width of pronotum posteriorly, ♂, 14.5 to 17 mm., ♀ 15 to 20 mm.

The following manuscript note by Prof. Stoner very surely refers to this species:

"Antigua, June 29, 1918. Found many specimens of a large brachypterous cockroach under rotten logs near a small fresh water pond about a mile from the dockyards." In a published note, Can. Ent., vol. LI, p. 217 (1919), the immediate environment of this roach is said to be in "low wooded areas, under dried leaves."

The following note by Prof. Stoner is interesting as bearing on the habitat of roaches, but unfortunately the species concerned are not specified:

"Antigua, June 24, 1918. Monk's Hill. On the wooded portion of this hill the trees are, in many places, quite close together; on these trees there grow small epiphytes looking something like small pineapple plants. These 'wild pines,' as they are called, hold water and moisture and insects of various kinds, among them cockroaches, find here a cool and safe retreat."

Family **Mantidæ**

(The rearhorses)

Genus Musonia Stal

Musonia surinamus Saussure

Thespis surinama Sauss., Mitth. Schweiz. Ent. Ges., vol. III, p. 70 (1869).
Mionyx surinamus Kirby, Syn. Cat. Orth., vol. I, p. 277 (1904).

This species, the correct generic assignment of which is as above, is represented in the collection by five specimens, one male and four females, all mature and collected on Barbados, the male without further data, one female taken in May and the others on May 14 on Pelican Island. The male agrees very exactly with a specimen of the same sex from Trinidad.

The following manuscript note by Prof. Stoner refers to this species:

"Barbados. Hawkins Estate. Heavy showers last few days have freshened vegetation and in low places took small green long-horned grasshoppers and *Mantis* sp. (?) juv."

Genus Thesprotia Stal

Thesprotia subhyalina Saussure

Oligonux subhyalina Sauss., Mitth. Schweiz. Ent. Ges., vol. III, p. 239 (1870).
Thesprotia subhyalina Kirby, Syn. Cat. Orth., vol. I, p. 277 (1904).

Fifteen specimens, one adult male, seven or eight adult females and the rest nymphs of various stages and representing both sexes, taken on Antigua in June are referred to this species. In the collection of the National Museum is a male of this species from Trinidad, a region between the type locally and that at which the present specimens were taken.

The tip of the long abdomen of this slender insect is very often broken off, as are those of the greater majority of specimens in this lot from Antigua. This loss must have been suffered either before collection or at that time, as the material was collected in spirits and remained unmounted until studied.

Material other than the above, not submitted to the writer, but presumably representing the same species, must have been taken as indicated in the following note by Prof. Stoner:

"Antigua, July, 1918. Hills and valleys, vicinity of English Harbor (village). A small grouse locust was taken in a low place near the main road, the first taken. Now and then a Mantis is taken and three species of Acridiids were taken in this situation." The mantids mentioned in this note may, however, refer to the specimens taken the preceding month.

Family **Phasmidæ**

(The walkingstick insects)

Genus CLONISTRIA Stal

Clonistria linearis Drury

Mantis linearis Drury, Ill. Nat. Hist., vol. I, pl. L, fig. 3 (1773).

Bacteria linearis Westwood, Drury's Ill. Nat. Hist., vol. I, p. 123, pl. L, fig. 3 (1837).

Clonistria linearis Kirby, Syn. Cat. Orth., vol. I, p. 351 (1904).

Pseudobacteria longiceps Kirby, Ann. Nat. Hist., (6), vol. III, p. 503 (1889).

Of this species there are twenty-six specimens in the collection, ten male and six female adults and ten nymphs of various sizes from Antigua, and one small nymph from Barbados without date. The material from Antigua was taken in June except two females which were taken on July 10 and 15.

Linearis was described and figured originally from a male specimen collected on Antigua. From that description and the accompanying little detailed figure it is difficult to make out the differentiating characters now in use. That they represent the species under consideration is fairly certain, however, since the present material is from the type locality, and the males agree very well with the original description and figure.

Whether or not the allied forms described by Stal and Bruner under the specific names *bartholomaea* and *sanctae-luciae* are specifically distinct is doubtful. That one of them, at least, is synonymous with Drury's species is very probable, since Bruner separates the females of both those forms diagnostically from *linearis* (which he places doubtfully as a synonym of *bartholomaea*) by the character of the operculum not exceeding the apex of the abdomen, a character certainly belonging to the females of *linearis* in the present collection. *Linearis, bartholomaea, guadeloupensis* and *sanctae-luciae* may all represent one and the same species, or each may be specifically distinct. Before this question can be decided definitely more material from regions occupied by them should be available for study, and the types of each should be seen where possible. As a commencement of the task of clarifying these matters a complete description of *linearis* as represented by the present topotypic material would have been drawn up except for the fact that all the specimens were preserved in spirits and were so shrunken and distorted in drying as to be rendered unsatisfactory for accurate description.

The following note by Prof. Stoner evidently refers to this species:

"Antigua, June 21, 1918. Vicinity Dockyards, English Harbor. Vegetation extremely xerophytic on the surrounding hills with many harsh spiny plants. In such situations collected several walking-sticks (the natives call them god-horses); a large *Schistocerca* (?) and a small Acridiid were also taken."

Clonistria sp.

There is a single female, apparently adult, in the collection bearing the same label as most the specimens of the species noted above, that is, Antigua, June, 1918, which is structurally very like *linearis,* but the head lacks the dark postocular stripes and the general color is darkened by many very small black dots and dashes. The slightly wrinkled appearance of the entire surface of the head, thorax and abdomen above and below is due to the coloration. This specimen may represent a new species, but is more likely one of the several allied forms occurring in the West Indies.

Family **Acrididæ**

(The shorthorned grasshoppers)

Genus Micronotus Hancock

Micronotus quadriundulatus Redtenbacher

Tettix quadriundulatus Redt., Proc. Zool. Soc. Lond., p. 208, pl. xvi, fig. 10 (1892).

Micronotus qadriundulatus Kirby, Syn. Cat. Orth., vol. iii, p. 53 (1910).

One dozen specimens of this tiny grouse locust were taken as follows: two males and one female on Antigua, one male on July 12, the others in June, but without other data; two males, six adult and one immature female from Barbados, all on May 16, except one pair in June.

This species was described from St. Vincent and has since been recorded from Haiti, Trinidad and Grenada. The dorsal undulations of the thorax are very distinct in some of the females and rather obscure in most males.

Genus Amblytropidia Stal

Amblytropidia stoneri n. sp.

Nine male and one female adults and an immature pair of a species of *Amblytropidia* collected on Antigua in June and July appear to be undescribed and are here dedicated to Prof. Dayton Stoner, the genial entomologist of the expedition and the collector of the specimens. It is a very distinct species running to *australis* in Bruner's keys in Biol. Cent. Amer., Orth., vol. ii, p. 62 (1904) and Proc. U. S. Nat. Mus., vol. xxx, p. 630 (1906). As a matter of fact it runs out in those keys to *australis* far better than does that species itself, to judge from a single female specimen of *australis* from Paraguay in the collection of the National Museum. In this female of *australis,* determined by Prof. Bruner, the median carina of the vertex is scarcely as prominent as in the United States species *occidentalis;* in the species here described this carina is decidedly more prominent than in either *australis* or *occidentalis.*

The abbreviated organs of flight will serve for the easy differentiation of this species from allied forms.

Description.—Male: Head scarcely ascending, barely if at all elevated above the level of the pronotum; fastigium of the vertex beyond the narrowest point about twice as long as broad, apically, narrowly rounded with distinctly elevated margins and a very strong median carina, which, however, fades out before extending over much more than half the length of the occiput; frontal costa narrowed slightly mesially and sulcate almost to the clypeus and very nearly to the point of mergence with the fastigium; eyes about twice as long as the greatest width, narrowing apically, the anterior border almost straight; antennæ scarcely longer than the head and pronotum together and noticeably flattened, especially basally, where several of the segments are somewhat broadened. Pronotal disk truncate anteriorly, obtuseangulate posteriorly and with persistent and well elevated median and lateral carinæ, the latter almost parallel and the median carina severed by two transverse sulci, the posterior one of which is situated behind the middle; lateral lobes slightly longer than high, the lower margin slightly rounded and very gently ascending anteriorly, the anterior and posterior margins diverging upwardly, the anterior margin decidedly more so than the posterior one; prosternum with a flat subquadrate plate; mesosternal interspace subquadrate, that of the matasternum closed posteriorly.

Legs rather slender; posterior femora regularly but not very noticeably marked on the outer face by diagonal concolorous ridges meeting on the median line to form basally directed obtuse angles; apical angles rounded, the genicular angles acuteangulate; posterior tibiæ with from eleven to twelve spines on the outer superior margin, the opposite margin with eleven spines besides the two longer apical calcars.

Organs of flight decidedly abbreviated; tegmina not much exceeding the pronotum in length and leaving a fourth or more of the abdomen exposed; the shortening of the tegmina is due apparently to a reduction of the apical portion, which results in the intercallary area, with its rather distinct intercallary vein, extending almost to the tip of the tegmen; humeral area only very moderately expanded and furnished with somewhat regularly disposed subparallel transverse veins; costal area broad and extending the entire length of the tegmen and with irregular subparallel diagonal veins; the ulnar veins of the tegmina are stout and separated for about their basal third or half, beyond which point they are fused, the space between their separated bases forming a rather noticeable area; wings about one-half as long as the tegmina, but well formed and with distinct venation, the anal and middle areas folding fan-like when closed.

Abdomen moderately slender and dorsally subcarinate; supraanal plate elongate-triangular, the sides straight, dorsally longitudinally shallowly sulcate mesially between two low ridges, the lateral margins elevated slightly, especially basally, where the plate is laterally compressed to form a small lateral oval area; subgenital plate much elongated, somewhat narrowly pointed and extending considerably beyond the supraanal plate and cerci; cerci simple, but little over twice as long as broad, very slightly flattened and tapering to a moderately sharp point.

General coloration wood-brown; eyes generally slightly darker than the general color; disk of lateral lobes, especially in the upper portions, a postocular stripe on the side of the head, the anterior longitudinal half of the tegmina on its basal half or more and the upper half of the outer face of the posterior femora sometimes darker than the general coloration, but this is not at all a constant character, those portions enumerated often being but little contrasted with the rest of the insect's coloration; the tips of the posterior femora are very constantly fuscous and the spines of the legs are piceous in the apical half.

Female: Very like the male moth structurally and in coloration, and in the latter respect would very surely exhibit about the same range of variation as described above in the case of the males were more specimens available for examination. The unique specimen before me, however, has the sides of the head, the lateral lobes of the pronotum and the outer face of the posterior femora of a uniform light green, the femora apically darker. The sternal interspaces no broader than the males. Antennæ noticeably shorter than in the male. Organs of flight very like those of the opposite sex, but slightly shorter as compared with the pronotal length. Ovipositor with the upper scoops somewhat longer than the basal depth, the superior margins unarmed, the tips curved somewhat upwards.

Measurements: Length, pronotum, ♂, 4 to 4.75 mm., ♀, 6 mm.; posterior femora, ♂, 11.5 to 13 mm., ♀. 17 mm.; tegmina, ♂, 8 to 9 mm., ♀, 9.5 mm.; antenna, ♂, 8 to 8.5 mm., ♀, 8 mm; width, pronotum across the posterior part of the disk, ♂, 2 to 2.25 mm., ♀, 3 mm.; tegmina, spread, at widest point, ♂, 2.25 mm.,

Type, male, Antigua, June 24; allotype, female, same locality, July 5; paratypes a to h, males, same locality, a and b on June 24; c, June 26; d to f, July; g, July 1; h, July 5; paratypes i and j, nymphs, i, male j, female, both same locality in June.

Type, allotype and paratypes a, b, g and i in collection United States National Museum, the remainder of the material in the collection of the University of Iowa.

Catalogue No. 25140 U. S. N. M.

This species may be the one recorded from the nymph only by Prof. Morse, Psyche, vol. XII, p. 19 (1905), from the Bahamas as *Amblytropidia* sp.

Genus Orphulina Giglio-Tos

Orphulina balloui Rehn

Orphulella balloui Rehn. Ent. News, vol. XVI, p. 178, pl. VIII, fig. 2, 3 (1905).

Orphulina balloui Kirby, Syn. Cat. Orth., vol. III, p. 118 (1910).

A large sires of this species was taken, 25 male and 16 female adults and one male and three female nymphs on Barbados in May and June, the only day dates noted being June 15 and 16. The two nymphs, one small one and one an apparently full grown pupa ready for final transformation, were labelled merely "May," as were about one-half of the adult specimens. A single specimen, a female, was of the green phase of coloration.

This species superficially resembles the following one, but it is really very distinct specifically. Generically it is not so well differentiated, though the characters enumerated by the author of the genus, Boll. Mus. Torino, vol. IX, No. 184, p. 9 (1894), for the separation of these two genera are amply sufficient for the purpose, though there is some variation in the width of the mesosternal interspace. The antennal length, etc., as used by Bruner in Biol. Cent. Amer., Orth., vol. II, p. 30 (1902) are not nearly so diagnostic as those used by Gigilo-Tos, especially the more elongate mesosternal interspace, longer head and more persistent frontal costa in *Orphulina*.

Genus Orphulella Giglio-Tos

Orphulella punctata DeGeer

Acrydium punctatum DeGeer, Mem. Ins., vol. III, p. 503, pl. XLII, fig. 12 (1773).

Orphulella punctata Kirby, Syn. Cat. Orth., vol. III, p. 121 (1910).

Twelve male and seven female specimens of this common and widely distributed species were taken on Antigua, labelled datically as follows: one male, June; one male and two females, June 24; two females, June 26; seven males and three females, July; two males, July 1; one female, July 5.

Three females only are green, all the rest being of the brown phase of coloration.

Genus Schistocerca Stal

Schistocerca columbina Thunberg

Gryllus columbinus Thunbg., Mem. Soc. Petersb., vol. IX, p. 399, 425 (1824).

Schistocerca columbina Kirby, Syn. Cat. Orth., vol. III, p. 455 (1910).

This locust is represented in the collection by a series of nine male and eight female adults and two male nymphs which are probably this species, all taken on Antigua, one female on June 21, three pairs on June 24, four males and three females on June 26, two males and one female on July 1 and the nymphs in June, the day not stated.

This series shows very little variation. The maculation of the tegmina varies somewhat in distinctness and the general coloration of some specimens is lighter than in others. The pronotal disk is usually unicolorous, but sometimes there is present an obscure posteriorly narrowing longitudinal lighter streak; lateral lobes unicolorous or the lower portion slightly lighter, and a slightly darkened area mesially on the anterior portion of the lobe. The sides of the head have a blackish subocular stripe much less conspicuous than in *pallens*. The posterior femora are usually white on the outer face, but rarely they are brown, similar to the general coloration. The pronotal disk is acute posteriorly, but there is some slight variation in this respect.

Schistocerca inscripta Walker

Cyrtacanthacris inscripta Walk., Cat. Derm. Salt. Brit. Mus., vol. III, p. 550 (1870).
Schistocerca inscripta Kirby, Syn. Cat. Orth., vol. III, p. 455 (1910).

Three males and two females of this species were taken by the expedition, all from Antigua, the females on July 3 and the males on July 1, 5, and 10.

This species resembles *americana*, but is noticeably smaller; it may eventually prove to be but a smaller form of that widely distributed species. These Antiguan specimens agree with ones from Jamaica, the type locality. Some variation is noticeable in the clearness of tegminal maculation and also in the variegation of the lateral lobes of the pronotum.

Schistocerca pallens Thunberg

Gryllus pallens Thunbg., Mem. Acad. Petersb., vol. V, p. 237 (1815).
Schistocerca pallens Kirby, Syn. Cat. Orth., vol. III, p. 460 (1910).

A fine series consisting of 22 males and 13 females, also two large female nymphs probably of this species, were brought back by the expedition. One male comes from Antigua, taken July 12, and all the rest are from Barbados, 15 males and 8 females on June 16 and the rest with only the month date of June and a single pair taken in May.

This species seems very uniform in having the costal area of the tegmina immaculate; the clearness of tegminal maculation varies somewhat, but here, too, the variation is slight. The marking of the pronotum, however, is decidedly variable, especially on the disk where the color ranges from a wholly unicolorous brown to a very conspicuous longitudinal yellowish stripe; the lateral lobes are mesially marked with blackish, which mark is unicolorous, or with a central white streak; the vertical subocular black streak is a constant and conspicuous feature of the coloration.

It appears probable that a number of specific names will eventually fall into synonymy under *pallens* when a thorough revision of the genus is made. Scudder, in his revision of 1899, Proc. Amer. Acad. Arts and Sci., vol. XXXIV, p. 441-476, refers with a query the species *cubensis* Sauss. and *pectoralis* Walker, to the synonymy under this species, but Kirby, in his recent catalogue, lists *cubensis* as a distinct species and places *pectoralis* in synonymy under a name still older than *pallida,* the *rustica* of *Fabricius.* A thorough revision of this genus, based on a study of typical material so far as possible, is much to be desired.

Notes made by Prof. Stoner in Barbados under dates of May 15, 16, 20 and 22 refer wholly or in part to *pallens.* These notes are here copied verbatim:

"*Barbados.*

15 May, 1918. Found large grasshoppers *(S. pallens)* and the field cricket *(G. assimilis?)* not uncommon in the small cane fields and grassy plots in the suburbs of Bridgetown.

16 May, 1918. On high land out Hastings Way about 4 miles from Bridgetown sour grass is grown abundantly and in these fields *S. pallens* was abundant, though exceedingly wary and difficult to catch. The insects are protectively colored; rise up again quickly after alighting if they are pressed; if they alight, crawl for some distance in the under grass before flying again. When secured in the net will leave it like a shot if the opening is not kept closed.

These dry uplands furnish a few conocephalids and also some *O. balloui.* in low places around ponds or along the few small open streams found a few green long-horned grasshoppers.

20 May, 1918. Even on the bare, dry hills heavily pastured by goats and cattle *S. pallens* was not uncommon. (St. Michael's Parrish).

22 May, 1918. Hawkins Estate. *S. pallens* common on high, dry hills."

Family **Tettigonidæ**

(The longhorned grasshoppers)

Genus NEOCONOCEPHALUS Karny

Neoconocephalus guttatus Serville

Conocephalus guttatus Serville, Ins. Orth., p. 518 (1839).

Conocephaloides guttatus Kirby, Syn. Cat. Orth., vol. II, p. 242 (1906).

Neoconocephalus guttatus Karny, Abhandl. k. k. Zool.-Bot. Ges. Wien, vol. IV, pt. 3, p. 24 (1907); ID, Wytsman's Gen. Insectorum, Fasc. 139, pl. VI, fig. 13 (1912).

Two specimens, both males, from Antigua, one on July 15, the other in July, with the day not recorded.

Neoconocephalus triops Linnæus var. *macropterus* Redtenbacher

Conocephalus macropterus Redt., Verh. Zool.-Bot. Ges. Wien. vol. XLI, p. 381, 402 (1891).

Conocephaloides macropterus Kirby, Syn. Cat. Orth., vol. II, p. 245 (1906).

Neoconocephalus macropterus Karny, Abhandl. k. k. Zool.-Bot. Ges. Wien. vol. IV, pt. 3, p. 27 (1907).

Two males, two female adults and two immature females of this form are present in the collection, all from Barbados, the nymphs in May, the day not indicated, the two males and one female on May 16 and the other female on June 14.

One of the males is of the brown color phase and tends strongly towards the variety *fusco-striatus* of Redtenbacher.

There is no doubt in the mind of the writer that this is a variety of the *triops* complex. *Triops,* with its synonyms *mexicana, obtusus* and *dissimilis,* has the vertex blackish beneath at the apex, as has also the color-form *fusco-striatus;* this ventro-apical darkening of the vertex fades gradually, as easily observed when a series of specimens are studied, to a wholly unicolorous vertex. Specimens in which the vertex is without ventro-apical infuscation are determinable as *macropterus* and occur in both green and brown phases of coloration.

Contiguus Walker is a recorded synonym of *mexicana,* which is a synonym of *triops,* and it is almost certain that several other names in this genus will eventually be found to be synonymous with *triops* or some of its varieties.

Genus Conocephalus Thunberg

Conocephalus cinereus Thunberg

Conocephalus cinereus Thunbg., Mem. Acad. Petersb., vol. v, p. 273 (1815).

Anisoptera cinereum Kirby, Syn. Cat. Orth., vol. II, p. 276 (1906).

Conocephalus cinereus Karny, Wytsman's Gen. Insectorum, Fasc. 135, p. 13 (1912).

Conocephalus cinereus Rehn and Hebard, Trans. Amer. Ent. Soc., vol. XLI, p. 243, pl. XXII, fig. 12, and pl. XXIII, fig. 5, 6 (1915).

Of this common West Indian species there are 26 specimens in the collection, four males, seven females and three nymphs from Barbados in May, and four males, seven females and one nymph from Antigua in June and July.

The adults of the above material are brachypterous except a single male specimen from Barbados, taken May 16.

The "small, green, long-horned grasshoppers" referred to in the note quoted under *Musonia surinamus* on a previous page, obviously refer to the present species.

Family **Gryllidæ**

(The crickets)

Genus Neocurtilla Kirby

Neocurtilla hexadactyla Perty

Gryllotalpa hexadactyla Perty, Delect. Anim. Art., p. 119, pl. XXIII, fig. 9 (1832).

Neocurtilla hexadactyla Kirby, Syn. Cat. Orth., vol. II, p. 2 (1906).

One adult and thirteen nymphs, fresh water pond, English Harbor, Antigua, June 28, 1918.

One of the above nymphs has but three dactyls on the anterior tibiæ.

Genus Scapteriscus Scudder

Scapteriscus abbreviatus Scudder

Scapteriscus abbreviatus Scudd., Mem. Peabody Acad. Sci., vol. I, p. 14, pl. I, fig. 8, 20 (1869).

Scapteriscus abbreviatus Kirby, Syn. Cat. Orth., vol. II, p. 2 (1906).

One adult female bearing a label reading: "*Scapteriscus variegatus*" and the legend "B 1047. 013.", all in black ink except "013," which is in red ink. This specimen may not be from the present collection, but this species occurs in the West Indies, as there is a female in the National collection from the

Bahamas, taken at Nassau by Dr. William Mann. At least the writer finds no characters at variance with those exhibited by material taken in Florida.

Abbreviatus may have to fall as a synonym of Burmeister's *variegatus.* That species is described as having wings superceeding somewhat the tegmina, but a specimen recorded from Barbados by Rehn as *variegatus* is noted as having the wings shorter than the tegmina. The writer has seen no specimen fitting the description given by Burmeister, but the character of the wings being longer than the tegmina is given only in a diagnostic key and may not apply to this particular species, since some of the older writers, and too many of the recent ones, are prone to carelessness in placing units in keys. Then Mr. Rehn states that the tegmina of the *variegatus* from Barbados, a male, is very different in shape from that of *abbreviatus.* Thus there may indeed be two brachypterous species of this genus in the West Indies.

Genus Cycloptilum Scudder

Cycloptilum minimum n. sp.

The very small size and the unusually long wings are diagnostic of this little cricket, no other known form having the wings projecting a distance even one-half as great as the pronotal length. The maxillary palpi are also very different from those of allied forms.

Description.—Male. (the female unknown): Size decidedly less than any other known species of the genus. Head with the facial protuberance about as in *squamosum,* mesially divided by a vertical impressed line; maxillary palpi with the penultimate segment about equal in length to the apical one, the latter rapidly expanding to the scarcely obliquely truncate tip, this entire apical segment being scarcely, if any, longer than the apical width. Eyes about as in *squamosum.*

Pronotum very small and short, being no more than twice as long as the head; in allied forms it is distinctly more than twice, often three times, as long as the head; pronotal disk anteriorly truncate and posteriorly broadly rounded, the whole tapering somewhat posteriorly, but scarcely so much as in *squamosum.* Tegmina very large, projecting beyond the pronotum a distance but little less than the pronotal length, decidedly more than in other species of the genus; the tegmina are posteriorly slightly broader than the posterior width of the pronotum, not considering the deflexed lateral fields of the former; tympanum perfectly developed, occupying the whole of the exposed dorsal area of the tegmen; the apical curvature of the tegmen is approximately the same as that of the pronotal disk.

Anterior tibiæ without foramini, or with ones so small as to be seen only under high magnification; caudal femora more slender than in *squamosum*, especially in the apical portion; armature of caudal tibiæ about as in that of *squamosum*, the dorso-internal spurs scarcely, if at all, shorter than the ventro-external ones; posterior metatarsus rather long and slender, sulcate dorsally and armed on each margin with but three or four very minute serrations, the apical spurs about as in *squamosum*.

Abdomen not differing materially from that of *squamosum;* cerci broken off in both specimens examined.

General color yellowish brown with darker mottling; the tegmina with the apical margins irregularly mottled with black and the anterior longitudinal half of the lateral field is black.

Measurements: Length, total from front of head to end of abdomen, 5 mm.; pronotum, 1.9 mm.; elytra beyond the pronotum, 1.6 mm.; posterior femora, 3 mm.; width pronotum posteriorly, 2 mm.! posterior femora at widest point, 1.25 mm.

Type male, Antigua, June 1918; paratype a, same data.

Type in collection U. S. National Museum; paratype in collection University of Iowa.

Catalogue No. 25141 U.S.N.M.

Genus Anurogryllus Saussure

Anurogryllus antillarum Saussure

Gryllodes antillarum Sauss., Miss. Mex., Orth., p. 414, pl. VII, fig. 10, 13 (1874).

Anurogryllus antillarum Kirby, Syn. Cat. Orth., vol. II, p. 24 (1906).

One female, Antigua, in the month of June, day not noted.

Genus Gryllus Linnæus

Gryllus assimilis Fabricius

Gryllus assimilis Fabr., Syst. Ent., p. 280 (1775).

Gryllus assimilis Kirby, Syn. Cat. Orth., vol. II, p. 37 (1906).

Gryllus assimilis Rehn and Hebard, Proc. Acad. Nat. Sci. Phila., p. 295-320, pl. IV, figs. 1, 2, 4-9 (1915).

Fifteen specimens of this common and wide spread species were taken, distributed as follows: Barbados, in May, three male and five female adults; June, one male adult; Antigua, June, three male nymphs, July, one adult male and three immature females.

All of the above adults are macropterous. A thorough revision of this most variable of insects is given by Rehn and Hebard at the above cited reference.

Many synonyms are recorded of this cricket.

Genus ENDACUSTA Brunner

Endacusta (?) sp.

Ont adult male and a pair of immature specimens of a species of *Endacusta* were taken on Antigua in June. The genera in the group to which this gryllid belongs are to a considerable extent based on the presence or absence of foramina on the anterior tibiæ, or present on one or both sides, etc., characters probably of very little or no value and wholly undependable, in some cases being absent or present in the same species. On such characters the present insect runs out in Saussure's keys to the genus *Endacusta* in the case of the adult, that specimen having distinct foramina on the inner face of the fore tibiæ, but the nymphs of both sexes run to the genus *Phalangopsis,* having foramina on neither face of the tibiæ. There are males of *Amphicausta annulipes* in the collection of the National Museum with foramina on both faces of the tibiæ as there are supposed to be, and females of the same species, determined by Mr. Rehn, without foramina on either face. Thus there is, at present, such confusion in this group that it is thought best to consider the present form as an unknown species and refer it questionably to *Endacusta,* as the adult male appears to belong there. This adult has very short lateral pad-like tegmina, apically broadly rounded and of a leathery texture.

Genus HETERECOUS Saussure

Heterecous (?) *dubius* n.sp.

This cricket is placed in the genus *Heterecous* with considerable doubt, for if it really belongs here, it indicates that the genus was wrongly placed by its author, Saussure, among the non-musical forms, as the male has well developed stridulating organs. There is little doubt of the insect belonging to the subfamily Enopterinæ, the general facies being characteristic of the members of that group and the only feature at all at variance being the paucity of inter-spinal serrations on the posterior tibæ, as noted in the following rather complete characterization:

Description.—Male, (female unknown); head about as long as deep, vertical, the mouth inferior; vertex rostrate, of moderate length, the width scarcely one-half that of the basal segment of the antennæ, the dorsal margins parallel, the anterior margins diverging downwards; eyes prominent, narrowing ventrally; ocelli small and obscure; antennæ long and slender; palpi with the last three segments subequal in length, each being about as long as the combined lengths of the basal two, the apical one gradually expanding from the narrow basal portion to the broad apex, where it is about as broad as the length of that segment, the tip oval in section and deeply excavate.

Pronotum about as long as the posterior width, a little longer than the head and noticeably broadening posteriorly, the disk subsinuate posteriorly and broadly and shallowly concave anteriorly, rounding without distinct lateral carinæ into the lateral lobes, which are fully three times as long as high, with both lower angles rounded, the anterior ones the more so.

Tegmina fully developed, almost attaining to the tips of the posterior femora, and with a well developed tympanum; strigulatory vein but moderately heavy, mesially bent at rightangle; speculum opaque, fully twice as long as wide; wings exceeding the tegmina and surpassing the tips of the hind femora.

Abdomen of moderate size, the subgenital plate elongate, triangular, the ventral surface convex; cerci basally heavy and broad, thence tapering to an apically slender tip projecting well beyond the tip of the subgenital plate.

Legs stout; anterior and intermediate femora wholly unarmed, the posterior ones armed on the ventro-external margin only with a number of very small triangular teeth, five or six towards the apex the largest; anterior tibiæ with large open foramina on both faces, that on the outer face somewhat the narrower. The dorsal and ventral surface of the fore tibiæ are rounded and unarmed except for a short apical spine on each ventral margin; posterior tibiæ ventrally carinate mesially and finely and bluntly serrate, dorsally flat, gently broadened apically and both carinæ armed with seven or eight stout spurs, those of the inner margin much longer and extending further towards the base of the tibæ; between the large spurs of the outer margin there are a few small teeth, usually one between each two spurs, none on the inner carina except two or three very small ones towards the base; apical calcars of the posterior tibiæ three in number on each side, short, the outer ones much shorter than the tibial depths, the middle one the longer, the others very short; the inner ventral calcar about the same length as the corresponding outer one, but the upper and median ones are much longer than the corresponding outer ones, the median one being about one-half as long as the posterior metatarsus and almost as long as the tibial depth and the upper inner calcar noticeably longer than the median one, being slightly longer than the tibial depths; posterior metatarsus about twice as long as broad, apically slightly swollen and rounded above and below, above armed with two long stout apical spines directed upwards and backwards and with a pair of lateral calcars fully twice as long as the dorsal spines and more than twice as heavy, directed backwards and bearing many fine short hairs, as do also the two longer inner calcars of the posterior tibiæ, also microscopically true of other calcars; second tarsal segments of all the legs broadly expanded and ventrally concave; third tarsal segment slender, apically gently swollen, the claws basally broad and simple.

General color honey yellow, the abdomen is suffused with fuscous above and below, especially apically, and the lateral lobes of the pronotum have a blackish stripe extending along the upper portion along the cites of lateral carinæ; eyes black; extreme tips of spines and calcars of the legs dark and there is a narrow longitudinal black streak on the outer face of the posterior femora. The antennæ have certain of the segments very obscurely alternately darker and lighter.

Measurements.—Length, total, 18 mm.; pronotum, 3 mm.; posterior femora, 9.15 mm.; width, pronotum posteriorly, 3 mm.; posterior femora at widest point, 2.5 mm.

Type, male, Antigua, collected in July, the day not given.

Type in collection of the U. S. National Museum.

Catalogue No. 25143 U.S.N.M.

THE SCUTELLEROIDEA OF THE DOUGLAS LAKE REGION

Dayton Stoner

INTRODUCTION

The Scutelleroidea form an important and interesting part of the hemipterous fauna of almost every region. During the summers of 1919 and 1920 opportunity was afforded the writer for collecting and studying the scutelleroid fauna in the vicinity of the University of Michigan Biological Station situated on Douglas Lake in northern Michigan. The results are brought together in the form of the present annotated list which, based as it is on rather intensive collecting in a fairly well circumscribed area, should furnish data for more definite conclusions concerning the geographical distribution and natural history of these insects.

Field work was done during the months of July and August and the material thus secured affords the basis for this paper. Collecting was not attempted at a distance of more than fifteen miles from the lake. Without doubt other species of Scutelleroidea occur in the area herein discussed, although collecting was usually indulged in several times each week. Species which, from their known distribution, should presumably occur in the region, but which have not yet been recorded, are included at the end of this paper in a "Hypothetical List." Twenty-three species are at present represented from the region by specimens now in my collection. These are discussed in the following pages. A few words concerning topography, soil conditions, flora, etc., may be opportune at this point.

Douglas Lake is located toward the extreme northern end of the southern peninsula of Michigan, a little more than seventeen miles south of the Straits of Mackinac and about the same distance from Lake Michigan on the west and Lake Huron on the east. It lies in the Transition Zone, between the northern coniferous forest area and the central deciduous hardwood forest area. The immediate region of the lake where most of our collecting was done, is covered with glacial deposits and the soil is exceedingly sandy. Formerly, pine forests covered these sand areas but forest fires and lumbering have reduced the primeval forests so that, for the most part, aspens have now taken their places. Although extensive burned over areas with their thick growth of aspens, blueberry bushes and ferns occur all about the lake, pentatomids were not found in any numbers in such situations. But on the poorer soil which usually supports wild raspberry and blackberry plants and, perhaps, a thin stand of blue grass or red top, these bugs were most commonly found. There are few cultivated areas of any size in the region, but the ones which were visited yielded nothing of particular importance in the way of pentatomids.

The low, boggy land in the vicinity of Douglas Lake itself is of considerable extent and supports various types of semi-aquatic vegetation. In such situations a few thyreocorids and our most valuable find of all, *Sciocorus microphthalmus,* were taken. Arbor vitæ, tamaracks, spruces and a few balsams occur in these bogs and where the shade is dense little or no small vegetation suitable for plant feeding bugs is found. However, the narrow roadways and numerous trails which wind about in what seems to the newcomer an intricate maze are often grown over with more or less vegetation which offers food for some of the plant feeding forms.

In the vicinity of the lesser bogs, streams and lakes of the region various types of transitional plants occur. These link up the aquatic with the strictly terrestrial vegetation and such places afforded our best collecting grounds especially toward the latter part of the summer.

The sand beaches at various places around Douglas Lake are quite extensive and after some of the prolonged high winds pentatomids are occasionally found in the beach drift. At some points the beach, a few feet back from the water's edge is grown up in reeds and bunch grass, but such situations did not yield the cydnids that might be expected.

Most of the streams of the region are small, but along their moist banks in the cleared and burned over areas weeds, grasses and willows grow and collecting is usually good in such situations.

During the eight weeks that the Biological Station was open in the summer of 1918, the total rainfall was a little under 1.75 inches. As a result, much of the vegetation on the exposed sand dunes became parched and dry and was deserted by plant-feeding bugs. In spite of the somewhat greater amount of precipitation in 1920 the vegetation in such situations, especially after the middle of July, became hard and dry as during the preceding season.

A large share of the pentatomids mentioned in this paper are of transcontinental distribution, but a few of the forms are confined principally to northern latitudes. Among these may be noted *Elasmostethus cruciatus, Meadorus lateralis, Apateticus bracteatus* and *Podisus placidus,* all of which, with the exception of the first, are not particularly rare in the Douglas Lake region.

Acknowledgement is due the following persons for assistance in collecting material: Miss Priscilla Butler, Mr. E. H. Brunquist, Prof. H. C. Fortner, Mr. M. H. Hatch, Mr. H. W. Mossman, Prof. G. R. LaRue, Director of the Biological Station, and Mrs. Stoner, who was a constant aid and companion. Thanks are also due Dr. J. H. Ehlers, one of the botanists of the Station staff, for the identification of most of the plants herein mentioned.

ANNOTATED LIST

Family **Scutelleridæ**

Subfamily **Tetyrinæ**

Homaemus aeneifrons (Say)

This is probably the commonest species of Scutelleroidea found in the region and a large series of specimens taken at frequent intervals during July and August is at hand. The time of greatest abundance of the adults seems to be between July 20 and August 20. My earliest record for an adult is July 4. Several nymphs in third and fourth instars were taken up to July 15, but after that date the numbers of immature individuals gradually fell off. In my field notes of July 8, 1920, the following memorandum occurs: "Nymphs in third and fourth instars are common in open places in the woods on high, dry, sandy ground and also along the edges of woods north of North Fishtail Bay. Adults are also fairly common, but many of them are yet soft, indicating that the insects have but recently molted for the last time." The high, grassy hills south of Camp Davis offer excellent habitats for this bug, particularly during July.

However, not always were specimens taken in such arid situations for numerous examples are at hand from the vicinity of Smith's Bog, Bessey Creek near Ingleside and the small streams which flow into North Fishtail Bay.

Considerable variation in both size and coloration obtains in my specimens. The females average much larger and are more distinctly marked than the males, although one male in the collection is as distinctly marmorate as the best marked female.

Curiously enough, the closely allied species *H. bijugis* was not taken in the region, although northern Michigan is within its recorded range. It may be distinguished from *H. aeneifrons* by the yellowish marginal or submarginal line on the head, the rounded instead of angular anterior prolongation of the 6th visible ventral segment, the generally paler color and the slightly smaller size.

Subfamily **Odontotarsinæ**

Eurygaster alternatus (Say)

This scutellerid is also very common in open, dry grassy situations in the region, particularly on the higher ground. Nymphs far outnumber adults until the middle of July. My earliest record for an adult is June 29. On July 2, 1919, great numbers of nymphs in all stages were taken along the engineers' base line south of the Biological Station, while but two adults fell to our nets on this date.

The usual variation in size and color is exhibited by the specimens at hand. However, one of these, a female taken on July 17, is unique in having the scutellum, hemelytra and pronotum a uniform brick red in color with a round black dot at each humeral angle. In addition, the alternations on the connexivum are almost obsolete. Another specimen, a female taken

July 8, is suffused with pinkish, but the alternations on the connexivum are very well marked.

Family **Cydnidæ**

Although numerous and seemingly favorable habitats of the members of this family occur in the Douglas Lake region, the surprising paucity, both in individuals and in species is worthy of mention. The cultivated and uncultivated areas in low, marshy places in the open and along the woodlands would appear to offer excellent breeding and feeding places for thyreocorids; and one would expect to find cydnids on the sandy hills and lake shores. We were much disappointed on discovering the real situation, for the family is represented in our collection by but twenty specimens representing five species. These are the result of our efforts during the entire two seasons.

Subfamily **Thyreocorinæ**

Thyreocoris ater (A. and S.)

Nine specimens, four adults and five nymphs, are represented in my collection. In 1919 the first specimen of the season was a nymph in the second instar taken in a low, grassy creek bottom about two miles north of North Fishtail Bay on July 16. A low lying field of red top grass *(Agrostis alba)* just north of Ingleside proved to be our best collecting ground for the species, all our other specimens of this season having been taken here. On July 22 two adults and two nymphs were swept from the still uncut grass. One nymph is in the second instar, the other is in the fourth. Two days later another adult and a nymph were taken in the same place. An adult was discovered in beach drift near the Biological Station on June 30 by M. R. Hatch. In the Station records I find a specimen recorded from beach drift by R. F. Hussey.

This is the largest and shiniest species of thyreocorid in the region. The general form is broadly, regularly ovate and the punctures on the scutellum are not deep.

Thyreocoris nitiduloides (Wolff)

One of the members of my class in Entomology submitted a specimen of this species for examination and later a satisfactory exchange was effected whereby it became my property.

The specimen is a male, taken in August, and forms the only available record of the species for the region.

The present form is to be distinguished from *T. ater* by its smaller size, less broadly ovate form, deeper and denser punctuation and therefore less shiny appearance.

In general, this insect has about the same distribution as the preceding form, although it has not been so commonly met with in northern United States and Canada as *T. ater*. This indication of relative abundance and occurrence is borne out by our records.

Thyreocoris pulicarius (Germ.)

The first specimen of this species was taken just north of Ingleside July 22, 1919. The field was grown up in red top, together with a little timothy, and numerous plants of the bristly crowfoot *(Ranunculus pennsylvanicus)* were growing here and there. But one other specimen was taken during the remainder of the season; it was secured on August 6 in sweepings made in a low moist place a few miles west of Pellston. Specimens of the species were not taken during the season of 1920.

This form is considerably smaller (2.5—3.0 mm.) than either of the preceding, and is the only one here recorded in which the margins of the hemelytra are pale.

Subfamily **Cydninæ**

Cydnus sp.

A fragment of the prothorax, the front femora and tibiæ constitute the material which I include under the above generic name. Although I cannot associate these fragments with any species of cydnid in my collection, I feel that they were at one time possessed by a form either in or near this genus as it is now understood. These remains were found around the roots of wild rye *(Elymus canadensis)* growing along the beach west of Grapevine Point. Careful search was made here and elsewhere on several occasions during both seasons for living examples, but none were found.

Sehirus cinctus (P. B.)

But seven specimens were found during the entire two seasons of collecting. One specimen was taken July 7. The other six were taken in sweepings from weeds growing in a low place in a rye field July 18. The grain had just been cut and it is possible that the bugs may have moved from that to the weeds. Adjacent to the field was a pine and hardwood forest.

This is the largest cydnid that is likely to be found in the region, averaging about 5 to 6 mm. in length. In color, it is uniform bluish with white pronotal and costal markings and with abbreviated white lines on the outer sides of the tibiæ.

Family **Pentatomidæ**

Subfamily **Pentatominæ**

Sciocoris microphthalmus Flor.

It was rather a pleasant surprise to discover this typically Palæarctic species in the Douglas Lake region and it proved to be the best find of our two seasons' collecting. My earlier note concerning the occurrence of this rare pentatomid in Michigan (Ent. News, XXXI, 1920, 141) constitutes the first published record for the state. The following statement regarding its status is quoted from that note:

"This little pentatomid is one of the rarest and most interesting members of the North American heteropterous fauna but less than a half dozen definite locality records are known to me at the present time. Van Duzee (Trans. Am. Ent. Soc. XXX, 1904, 32) records a single specimen from the White Mountains in New Hampshire and Parshley (Fauna of New England, 14, 1917, 17) records a specimen from Maine. To these localities I am glad to add another, thus making known the further distribution of this insect within our borders.

"During the summer of 1919, I took four specimens of *Sciocoris microphthalmus* in the Douglas Lake region of northern Michigan. One of these, a male, was taken in the sweep net on July 9, and again on July 18, a male and a female were swept from roadside weeds growing in a wooded area along the edge of a small stream. One nymph, a male about one-third grown, was also taken on July 20 in a similar situation."

During the season of 1920 special effort was made to secure specimens in the situations where they were found in 1919, but in vain. One specimen, a female taken July 16 on the cement sidewalk at Camp Davis, the University engineering camp, constitutes our only record.

Apparently the species is not even locally common in the region, but it is very gratifying to know that it is not unlikely to be met with in the vicinity of the Biological Station. And it is also interesting from a zoological standpoint to note the extension of its range during the past fifteen years.

The small size (6.0—7.0 mm.), clypeate head, flattened and laminated connexivum and the rather short and bluntly rounded scutellum will at once distinguish this from any other Michigan pentatomid.

Peribalus limbolarius Stal

One nymph taken along the edge of an oats field near Riggsville, about four miles from Douglas Lake on July 29, 1919, constitutes our only record of this bug for the region.

The species is found generally throughout the United States and Canada. In most sections of the United States this is usually an abundant or at least common bug, and its apparent rarity here seems worthy of comment. However, in my experience in Iowa and other points farther west, the insect is commonly found in well cultivated districts. Not very many such areas occur in the immediate vicinity of Douglas Lake, but a number of excursions were made to outlying cultivated areas such as the one first mentioned, but with results as noted.

Chlorochroa uhleri Stal

This is another species which, in the adult stage, is not often met with in the region until the latter part of July. Indeed, adults of this form seem, in general, to appear later in the season than most other pentatomids and the height of abundance of adults occurs between July 15 and August 10.

Nymphs in the first and second instars were swept in considerable numbers from smooth sumach *(Rhus glabra)* on June 29, 1920. At this time also one adult was found. Often, too, nymphs and adults are found on blueberry bushes *(Vaccinium pennsylvanicum)* of which an abundance occurs in the vicinity of the Station. However, I am not sure that they feed on this plant, for several nymphs which I confined in a cage and furnished with fresh blueberry stalks daily could not be observed to feed upon them and died within a short time. In addition to sumach and blueberry, specimens were often taken from huckleberry *(Gaylussacia baccata)* in August.

At 11:00 A. M. on August 10, 1919, I found both adults and nymphs on the panicles of *Rhus glabra,* which grows in some abundance on the Biological Station grounds; the particular plot here observed consisted of about forty plants. Although I did not see the nymphs with the beak inserted in the fruit, I *did* note several *adults* with the beak thus inserted, and in the act of sucking. The following table will serve to give some idea of the abundance of these bugs on the plants in the plot based upon more or less regular intervals of collecting:

Time	No. adults taken	No. nymphs taken
11:00 A. M.	5	several
11:15 A. M.	8	
12:00 M.	2	
12:40 P. M.	2	
1:40 P. M.	3	
2:40 P. M.	1	
5:00 P. M.	2	3
7:50 P. M.	1	

Each time that the plot was visited it was inspected very carefully for adults, all of which were removed as soon as discovered. Apparently the Chlorochroas came in from nearby plants and areas to feed on the sumach fruit and, indeed, it seemed that the insects habitually *sought* these plants.

The green color of the bugs with the pinkish margins on pronotum, hemelytra and abdomen served to make the insects very inconspicuous against the reddish brown panicles and the green leaves of the sumach bushes. The bugs were very active on the date above mentioned, which was clear and very warm; if the collector approached too closely they dodged quickly to the opposite side of a panicle or dropped suddenly to the ground and "played dead."

On the morning of August 13 I took from the same plot of sumach bushes ten specimens of *C. uhleri,* all that I could find; and in the afternoon of the same day six more specimens, all adults and, curiously enough, all females. In my notes of July 15, 1919, I find the following statement: "*C. uhleri* and *E.*

euschistoides have been for four or five days and still are at the height of their abundance for the season."

The local status of this as well as other species of pentatomids seems to fluctuate considerably from season to season for, while the present form was very abundant during the season of 1919, only eleven specimens, of which but four are adults, were taken during the season of 1920.

Most of my specimens are typically colored, although a few have the hemelytra suffused with pinkish.

Mormidea lugens (Fabr.)

But one specimen, a half grown nymph taken on July 11, 1919, from the reeds at Sedge Point, represents this species.

The general distribution of the species would suggest that it should be found rather more commonly in the region than one would be led to believe from our single record. However, I have never found this to be a common form in any locality.

The adult may be distinguished from all other pentatomids in our fauna by the size (6.0—7.5 mm.), the general grayish olive color with two transverse abbreviated yellowish white lines anteriorly on the pronotum, and the black scutellum margined with yellowish white.

Euschistus euschistoides (Voll.)

Scarcely any habitat of the region is without its fair quota of individuals of this pentatomid, for it is one of the commonest and most generally distributed species as well as the most abundant member of the genus.

Adults are not uncommon in late June, though they become much more numerous later in the season, the height of abundance being between August 10 and 20. Apparently the species is double-brooded in this latitude, for half-grown nymphs have been taken as late as August 10. Nymphs in third and fourth instars are common up to about July 20; for several days after this adults are more plentiful, when again the nymphs become common.

This bug is often found on raspberry and blackberry bushes growing in the more or less open places in the woods, such as the burned-over area west of Bryant's Hotel and the partially cleared areas on Grapevine Point. Usually it is more abundant in the higher and more open ground than the following species, *E. tristigmus.* In the few cultivated districts about the lake this also proved to be the most abundant species of pentatomid. The grassy fields north of Ingleside and about Riggsville afford excellent habitats.

On numerous occasions during both seasons *E. euschistoides* was observed on the panicles of the sumach *(Rhus glabra),* particularly toward the middle of August. Many individuals, both nymphs and adults, were also observed with the beak inserted in the fruit of this plant, from which its owner was sucking the juice.

On occasions after high winds from off the lake numbers of these bugs could be secured in the beach drift near the Biological Station. No doubt the insects in attempting to rise in flight were caught by the breeze and carried out over the lake into which they fell, to be washed ashore later by the waves.

This pentatomid may be easily recognized from any other in the Douglas Lake fauna by its grayish color, small black spot at the lateral angles of the ventral abdominal segments and the deeply incised apex of the head.

Euschistus tristigmus (Say)

In low wooded places, or along the edges of such situations which have grown up in raspberry and blackberry bushes examples of this species are likely to be found in considerable numbers.

This also seems to be one of the species in which the individuals arrive at maturity comparatively late in the season. Nymphs are abundant and considerably exceed adults in number up to about June 20, after which time the latter are always common in proper habitats. Our earliest record for an adult is June 30, 1920, when one specimen was found in beach drift. A few other specimens have been taken in beach drift in July. Nymphs in second, third and fourth stages are usually plentiful on wild raspberry *(Rubus idaeus* var. *aculeatissimus)* at Grapevine Point during the entire summer. Other suitable habitats are the berry patches west of Bryant's Hotel and north of North Fishtail Bay, where the bugs are common until about mid-August. If the season is very dry, as often happens in the region, the numbers become much reduced.

The species also visits the sumach frequently, although not in such great numbers as *E. euschistoides,* but I have never seen it feeding upon this plant.

In the Station records for 1918, I find this form recorded on *Salix* by Hussey.

In this region this is the only member of the genus in which the venter is furnished with a row of black spots, which may be, in some cases, more or less obsolete.

Euschistus variolarius (P. B.)

While in Iowa, and, indeed, in most parts of the United States where the three species of Euschistus here mentioned occur, this is the most common representative of the genus, but two specimens are in my collection from Douglas Lake. I have seen but one other and that in a student's collection; it was taken on July 2 from grass growing along the east shore of Douglas Lake. My own specimens, both males, were taken July 15 and 16, 1920, in beach drift.

This species is to be distinguished from *E. euschistoides,* its nearest ally in the Douglas Lake fauna, by the absence of black points at the incisures on the edges of the abdomen, the usually rounded anterior margin of the head and the rounded median black spot on the genital segment of the male.

Coenus delius (Say)

Although this is a widely distributed and, in some parts of the United States at least, a fairly common species, it is one of the less familiar forms in the Douglas Lake region. The net result of our two seasons of collecting is but four adult individuals along with a number of nymphs. More of the latter might have been secured, but all the adults that were seen were taken.

Apparently this is one of the species which matures comparatively late in the season. My earliest record for an adult is July 7. Most of the nymphs were taken about the middle of July; one in the second instar was taken July 11, while another in the fourth instar was taken July 14. On July 17 an adult was taken in which the exoskeleton was still soft and yellowish, indicating that this individual had just molted for the last time.

It seems that the mortality among the nymphs is rather high or that the adults are more than usually secretive, for on the grass growing on the hills just back of Camp Davis and in the cleared areas north of North Fishtail Bay, nymphs in second and third instars are plentiful enough between July 4 and 11. However, later in the season when one would expect to find them in these situations, the adults are conspicuous by their absence. Neither were they to be found in any other situation. On a few occasions specimens have been swept from wild raspberry. Two adults were taken in beach drift in front of the Station on August 16, 1920.

This pentatomid may be distinguished by the regularly convex oval form, the slightly convex head with prominent median carina, the short rounded humeri, broad rounded apex of scutellum and irregularly reticulate venation of the wing membrane.

Neottiglossa undata (Say)

This is quite a common pentatomid in the region and we possess numerous adults taken during July. We have also a few nymphs in all instars taken after the middle of July.

Numerous examples are usually to be found on blue grass and red top growing in open places of the aspen association as well as on those grasses which may grow in low, more or less moist places such as the road through Reese's Bog and the fields north of Ingleside.

This is a small (4.5—5.0 mm.), easily distinguished pentatomid, dull yellowish in color, elongate oval in outline and presents a neat and trim appearance. Head convex with pale yellowish, calloused, longitudinal median line which extends backward on pronotum and scutellum.

Cosmopepla bimaculata (Thomas)

This is not a common bug in the region and the collector is not likely to take more than three or four specimens during the course of a day's work in the field.

My earliest record for an adult is July 7. I have taken a first instar nymph on July 11 and half grown nymphs as late as August 4. July seems to be the month in which the species is most likely to be met with. During this month it also breeds, for pairs have been taken in copula on July 22 and 29. On the latter date I took, in the vicinity of Riggsville, a specimen which had just molted for the last time, the body integument being yet soft and delicate.

On July 18, 1919, a specimen was swept from cinquefoil *(Potentilla monspeliensis)* growing in a low damp place in a rye field; again on July 8, 1920, several adults were taken in the same place on plants of this species. I have an adult which was taken on July 4 in beach drift near the Biological Station.

Apparently this pentatomid is most at home in low lying grass lands or semi-cultivated areas such as are found along Bessey Creek or north of North Fishtail Bay as well as, sometimes, along the shaded areas bordering woodland or in woodland.

C. bimaculata may be distinguished from any other pentatomid of the region by its size (5.0-7.0 mm.), and its general black coloration marked with reddish yellow.

Banasa dimidiata (Say)

One of the joys associated with collecting in the Douglas Lake region is the likelihood of meeting with considerable numbers of this beautifully colored pentatomid, especially during the latter part of July and also in August. It is during the first few days of August that the height of abundance of adults seems to be attained.

The favorite host plant here appears to be arbor vitæ *(Thuja occidentalis)*, which is a common tree along some portions of the lake shore as well as in other places. On August 8, 1919, many adults and nymphs, the latter mostly in the third and fourth instars, were swept from the small Thujas growing along the lake shore north of the Station. At this time, also, egg masses were found on the under side of the leaves of the Thuja. These egg masses usually contain from ten to twenty eggs placed side by side in the ordinary manner of pentatomid eggs.

The color of both nymphs and adults blends in very well with the color of the tree and the lighter green color of the cones, which latter, by the middle of August, are about one-half inch in diameter. Contrary to my observations on most pentatomids these insects do not "let go" suddenly when the tree upon which they are resting is beaten or disturben, but they seem to cling to it all the more tightly under such conditions. As a result I often found that, after beating the foliage of a tree thoroughly, I was able to obtain another specimen or two by shaking the branches very hard.

Toward the middle of August a few specimens of this species were taken from round-leaved dogwood *(Cornus circinata)* growing along the beach near Grapevine Point. The only other plants upon which I have taken the species in the region are blueberry *(Vaccinium)* and service berry *(Amelanchier canadensis)*.

During the summer of 1920 high winds seemed to be more prevalent than during the previous season and a good many insects were found in beach drift. There is no doubt that during these high winds flying insects of various kinds are caught by them and blown out on the lake, where they fall to the surface of the water, to be later washed ashore by the waves. In the first week of July, 1920, more pentatomids were found in beach drift near the Biological Station than during the entire season of 1919, and among this lot was a number of *B. dimidiata.*

This is the only greenish pentatomid of the region in which the basal half of the pronotum and more or less of the hemelytra are colored reddish or olive brown. Length, 8.0—11.0 mm.

Considerable variation in coloration is exhibited by the specimens in my collection. Recently molted adults are almost a uniform pale yellowish, the basal pronotal band being not yet well marked. In some fully matured examples the anterior half of the pronotum and the extreme tip of the scutellum are reddish brown.

Subfamily **Acanthosomatinæ**

Meadorus lateralis (Say)

Of this northern representative of our pentatomid fauna I have in my collection four specimens, two males and two females from the Douglas Lake region. All were taken between July 10 and 24, 1919. During the season of 1920 I saw but one specimen and that in a student collection; it, too, was taken in July.

One of my specimens, a female, was taken from a lily pad in the water of Douglas Lake. Another was taken in beating the vegetation growing along the edges of beach pools at Sedge Point. My other specimens were taken from vegetation growing in low and more or less swampy situations.

This is proportionately the narrowest and most linear of the Douglas Lake pentatomids and is not unlikely to be mistaken for a capsid. However, the present form has five antennal segments, while the capsids have but four. In addition *M. lateralis* is of a yellowish brown color mottled with reddish. Length, 7.0—9.0 mm.

Elasmostethus cruciatus (Say)

This is another typically northern representative of the group. While it is more widely distributed than *M. lateralis,* having been recorded as far to the southwest as New Mexico, it seems, in general, not to be so common as that form. I have but one specimen from the Douglas Lake region; it is a typically colored female taken August 2, 1920, in sweeping the vegetation along the low, swampy shore of the lake west of Bryant's Hotel. Mr. R. F. Hussey has told me of a specimen taken by him in the summer of 1918.

Subfamily **Asopinæ**

Perillus bioculatus var. *(b.) clauda* (Say)

On July 18, 1919, a Perillus nymph, probably of this species and the only representative of the genus taken during the summer, was swept from a low, grassy area in a field of rye which had been cut shortly before. This field was about one and one-half miles northeast of North Fishtail Bay and well out in the open cultivated district.

A single dead specimen, an adult male, was found on one of the shelves in Houghton Hall July 4, 1920. The bug had probably crawled into the building for protection at the time of hibernation, but had not been able to survive the rigorous Michigan winter. The antennæ of this specimen are entirely black.

This conspicuously marked black and red pentatomid is considerably larger than *C. bimaculata,* the only other black and red representative of the Scutelleroidea mentioned in this paper up to this time. The present form averages from 8.0 to 11.5 mm. in length.

Perillus exaptus (Say)

I have one specimen of this species in my collection, a female taken July 24, 1920, by M. H. Hatch, at Big Stone Bay in Emmet County. The light markings are reddish yellow with the extreme margins of pronotum, hemelytra and connexivum palest. The anterior femora are armed with a very low blunt tubercle in place of the stout spine characteristic of the preceding species.

Apateticus cynicus (Say)

This is the largest, although apparently one of the less common pentatomids of the region. A female which I have measures 19.0 mm. in total length; the males average somewhat smaller. I have but two specimens, a male and a female. The latter was taken in beach drift July 26, 1919, while the male was picked from the clothing of a visitor at Grapevine Point, August 13. Specimens of the species were not taken during the 1920 season.

Apateticus bracteatus (Fitch)

This is the more common of the two larger forms of this genus which occur in the region, a series of eight adults representing our efforts for the seasons of 1919 and 1920.

My best haul of this species was made on July 16, 1919, when I took four adults, two males and two females, in addition to a fourth instar nymph. They were swept from willows growing in a low, swampy, uncultivated area about one and one-half miles north of North Fishtail Bay. On either side of this narrow area a forest fire had burned—indeed, it was still smoldering on this date. One of the adults had apparently just cast the last nymphal skin for the body integument was still soft and a little paler than usual. My other specimens, with the exception of two, have been taken on willow. A single female was found in beach drift July 22 and, by a curious coincidence, my only adult specimen taken in 1920 was found in a similar situation on the same date in July.

In accordance with my delimitation of this form I have included here specimens which average somewhat smaller than the preceding and in which the vaginal plate of the female is triangular rather than quadrate. The general coloration in the present form is a somewhat reddish yellow; however, none of my Douglas Lake specimens are as dark as some from Oregon, which are in my collection. As between the two representatives of the genus found at Douglas Lake, the present form has the humeri somewhat less attenuate than in *A. cynicus,* although the humeri of both are about equally acute. All my specimens of *A. bracteatus* have the anterior pronotal margins more strongly crenulate than in *A. cynicus.*

Podisus maculiventris (Say)

At no time during our stay at Douglas Lake was this bug common, although in most places in the United States and Canada it is the most abundant member of the genus. Adults are likely to be met with after the middle of July in low grassy places such as lake borders and bogs. I took several along the shore of Lancaster Lake on July 20, at which time also a number of nymphs in third and fourth instars were secured. Several times I have taken the species from willow *(Salix).* I have four specimens that were taken in beach drift near the Biological Station.

P. maculiventris may be separated from the following species by its larger size (10.0—14.0 mm.), and the proportionately longer ventral spine which extends forward between the posterior coxæ.

Podisus modestus (Dallas)

This is the smallest representative of the subfamily in the region, averaging in length from 7.0 to 10.0 mm. It is also a little paler than the preceding form and shares with it the distinction of having the wing membrane marked by a longitudinal brownish vitta. I have but eight specimens, all but one of which were taken after the middle of July. One adult was taken in beach drift on July 11.

Podisus placidus (Uhler)

So far as the Douglas Lake region is concerned this seems to be the commonest representative of the genus and during the latter part of July and all of August it may usually be taken in low, more or less swampy areas; oftentimes it is to be found in such areas which have been burned over some months previously and have since been permitted to grow up in weeds and grass.

My earliest record for an adult in the field is July 24, when I secured these forms as well as nymphs from balsam poplar *(Populus balsamifera).* One specimen in my collection was taken in beach drift July 17. As with *P. maculiventris* I have on numerous trips taken this form on willows growing in low places. On one occasion I took a specimen from white cedar *(Thuja occidentalis)* growing along the east shore of Douglas Lake. Often grassy areas among the aspens will yield a number of these bugs.

During the season of 1920 several adults and nymphs were captured on August 9 in the low, swampy, burned-over areas surrounding Smith's Bog. No other Podisus was taken in this situation.

This bug is to be distinguished from its congeners by the form, which is broader than usual behind the middle, by the blunt, rounded humeri and by the lack of a dusky longitudinal vitta on the wing membrane. Length, 9.0—11.0 mm.

HYPOTHETICAL LIST

I have added the following hypothetical list of species simply to indicate to the prospective student of the group the desirability of being on the lookout for them in the Douglas Lake region. Those species are here included which, although not at present represented in our collections, would seem from what is already known of their distribution, likely to be met with in the region. Possibly further collecting extending over a period of years will reveal at least some of the forms mentioned below; also, perhaps, other species than the ones here listed may be added.

Family **Cydnidæ**

Subfamily **Thyreocorinæ**

Thyreocoris lateralis (Fabr.) Has been recorded from Michigan.

Subfamily **Cydninæ**

Pangaeus bilineatus (Say)
Amnestus spinifrons (Say)
Amnestus pusillus Uhler

Family **Pentatomidæ**
Subfamily **Graphosomatinæ**

Podops cinctipes (Say)
Podops parvulus (Van D.)

Subfamily **Pentatominæ**

Brochymena arborea (Say)
Brochymena quadripustulata (Fabr.)
Trichopepla semivittata (Say)
Hymenarcys nervosa (Say)
Menecles incertus (Say)
Thyanta custator (Fabr.)
Acrosternum hilare (Say)

CONCLUSION

In conclusion it may be of some interest from the standpoint of geographic distribution to compare the pentatomid fauna of the Douglas Lake region in Michigan with the pentatomid fauna of the Lake Okoboji region in northwestern Iowa, at which place I have also made a study of the group.

Although the two regions are rather widely separated—Lake Okoboji is about 500 miles west and 175 miles south of Douglas Lake—and the floral and geological conditions are somewhat different, both are lake regions. In addition, our collecting was undertaken for about the same length of time at each place and during the same season of the year, so that a reasonable basis for comparison is available.

Perhaps a brief quotation from an earlier paper on the Lake Okoboji pentatomids* will suffice for a general explanation of conditions at that place. "The vicinity of the Macbride Lakeside Laboratory (on West Okoboji Lake) offers excellent collecting grounds all within easy access. Indeed, so many ecological areas are seldom found within so circumscribed a region.

Deep woods, swamps, sandy beaches, high rolling prairies with their respective types of flora—all are within one's ability to investigate. . . . ."

It may be mentioned in passing, that coniferous trees are totally lacking in the vicinity of Okoboji, which lies just within the lower boundary of the Transition Zone (Alleghanian), the Upper Austral (Carolinian) becoming evident only a few miles to the south.

	Genera in list	Genera common to both places	Species in list	Species common to both places
Douglas Lake Region	19	14	23	17
Lake Okoboji Region	19		29	

* Stoner, Dayton, The Pentatomoidea of the Lake Okoboji Region, Bull. Lab. Nat. Hist., S. U. I., VII, No. 3, 1917, 39-47.

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CONTENTS

THE ENDOSPERM OF UTRICULARIA

By Robert B. Wylie and Alice E. Yocom
Department of Botany, University of Iowa

Studies related to seed production remain among the fundamental lines of botanical investigation. The potential value of such information in relation to plant breeding and crop production calls for critical and, if need be, repeated investigation of all problems that may shed any light on the structures and activities related to reproduction in higher plants. Interest is stimulated also because of insufficient information concerning some of the events taking place in the embryo-sac, and uncertainty as to the precise function of some of the parts concerned.

The general uniformity of events centering about seed production in Angiosperms is undoubtedly significant, though capable of various interpretations. The practically uniform behavior of both the male and female gametophytes in such different groups as Monocotyledons and Dicotyledons still seeks explanation. These divisions of the great Angiosperm group are at present widely divergent in many respects, yet the structures immediately related to their reproduction are almost identical. It may be, as would at first appear, that such conditions point to a common past and suggest that adaptation is as yet incomplete. It is hardly conceivable though that any known antecedent structure so resembled the eight-nucleate embryo-sac as to dominate its present behavior. If inherited tendencies prevail why not a larger development within the nucellus as in Gymnosperms? On the other hand why is it not reduced to simply an egg?

There must, then, be hindering factors on the one hand to inhibit marked development of the female gametophyte of the Angiosperm. On the other hand further reduction seems to be inconsistent with its successful operation; accessory parts seem necessary aids to fertilization and nutrition of the early stages of the embryo. Constancy of the gametophyte is a com-

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promise between these opposing tendencies and one comes to feel that it is held rather sharply in check by environing circumstances. That it tries frequently to escape its bonds is evidenced by the numerous departures from the typical story. There are recorded observations of unusual behavior by each of the seven nuclei associated with the egg, and there are various modifications of the gametophyte as a whole. Granted favorable opportunity one might expect to find it taking on highly modified forms.

In the Bladderwort (*Utricularia*) an unusual combination of parts is found within the ovary, and associated with it are striking specializations of both the female gametophyte and its successor in place, the endosperm. The protruding embryo-sac of *Utricularia* has long been known, as it was figured by Mertz (7) twenty years ago. Similarly, Kamienski (5) long since outlined quite fully the remarkable behavior of the endosperm in this genus. Lang (6) finds in the closely related *Polypompholyx* a series of events parallel to those in *Utricularia,* yet displaying interesting points of difference of peculiar significance in this connection. The present writers have undertaken this study feeling that the unusual behavior of these structures merited fuller investigation and perhaps warranted further conclusions.

Living vegetatively as a submersed aquatic, *Utricularia* has long been of interest because of the peculiar bladders produced upon its leaves. These organs, which function as floats and insect traps, have suggested both the common name of the plant and the scientific name of the genus. While belonging to the limited group of seed plants that flourish vegetatively beneath the surface of the water, its flowers are brought to the surface of the water for pollination, and pollen transfer is accomplished in the air by insects.

Utricularia vulgaris americana Gray thrives in our Iowa lakes and ponds. In the vicinity of the Iowa Lakeside Laboratory on the Okoboji lakes in northwestern Iowa the smaller bodies of water are often yellow with its bloom. The flower stalk begins its development beneath the surface but later pushes up out of the water to a height of four to fifteen inches, bearing a raceme of beautiful flowers. As the period of flowering passes, the fertile stalk is gradually submerged, either sinking slowly or tipping over bodily into the water. The seeds thus carry out most of their development in air, invested by the tough capsule of the ovary wall, but are soon submerged through the sinking of the entire inflorescence.

FLOWERS AND POLLINATION

The flowers are bright yellow in color and offer many specializations for cross pollination. They are distinctly zygomorphic, with a strongly lipped corolla bearing the stamens, a tubular style, and a lipped stigma with numerous stigmatic hairs beneath the upper lip. Insect visitors seem to be responsible for pollination, and the writers could find no evidence of cleistogamy in this species. Flowers opening in hooded bags which prevented the visits of insects, were uniformly sterile.

While insects are numerous about the flowers of *Utricularia* most of them merely perch upon some part of the inflorescence. The damsel flies, for example, regularly use the flower stalks as places of temporary rest from flight. The only insect observed to enter the corolla was a small buff-colored fly, the species of which was not determined. These insects are numerous about the beds and were repeatedly observed to enter the closed throat of the corolla, disappearing within the flower and, after an interval of nearly a minute, to emerge and wing their way to other blossoms of the kind. Fertilization seems to be regularly accomplished and of the hundreds of ovaries sectioned few showed sterile ovules. Abortive embryos are not uncommon but this condition seems to be due mainly to crowding and possibly to loss of nutritive connection through partial displacement, rather than to failure of pollination.

Much of the material for this study was killed in one per cent chrom-acetic acid, run through the alcohols and imbedded in paraffin. The sides of the ovaries were clipped so as to invite the free penetration of reagents into the cavity of the ovary. For critical study of fertilization and early post-fertilization stages, material was killed in Flemming's stronger solution. This was incomparably better, and practically all the figures were drawn from material fixed in this way.

PLACENTA AND OVULES

The globular free central placenta rising from the base of the flower is covered with ovules (*Fig. 1*). The number as counted in seven flowers ranged from 175 to 250 with an average of 227. Of these seven flowers, five showed abortive ovules, twenty-eight of them being recognized, all told, but of these, nineteen were in one flower.

The ovules are anatropous and each possesses a single massive integument which arches over and comes into contact with the placenta (*Fig. 6*). At first rather delicate (*Fig. 2*), the integument thickens and soon, as seen in sections, becomes similar to the opposing funicular part, each being hemispherical, with the embryo-sac as a central axis between these halves (*Fig. 11*).

These spherical ovules are tightly packed together, completely covering the free central placenta and thus appearing as a globular mass which, however, is closely invested externally at all stages by the ovary wall.

In the growth following fertilization the ovules become sharply angled together. The seeds are commonly six sided (*Fig. 17*) and are clearly flattened dorsiventrally, due to compression between the placenta and the investing ovary wall (*Fig. 10*).

The funiculus, early massive and typical of this type of ovule (*Fig. 6*), diminishes relatively during the development of the seed and finally consists of merely a slender rudimentary structure (*Fig. 16*). No vascular elements are developed in the funiculus, or in any other part of the ovule, though they are soon prominent in the placenta as discussed below. It should be kept in mind that the funiculus of the ovule of *Utricularia vulgaris* thus early aborts and that the embryo is nourished through another structure, the micropylar haustorium, the developing seed meanwhile being held in position by the pressure of surrounding parts.

The tissues of the free central placenta undergo considerable specialization. A tree-like vascular supply is developed which sends a branch to a point near the base of each ovule. The tip of this branch is directed towards the funiculus but stops alongside the micropylar haustorium (*Fig. 1*).

That portion of the placenta immediately beneath the ovule begins modification before the megaspores are formed. An ovoid mass of tissue, involving a thousand or more cells, begins to stain more deeply and soon becomes sharply delimited from the surrounding tissue, the cells differing both in size and shape as well as staining reaction (*Fig. 11*).

This mass of tissue may include several thousand cells destined to receive the micropylar haustorium and is thus clearly marked out long before fertilization has taken place. Its later behavior will be taken up with discussions of the female gametophyte and the endosperm. The cells adjacent to this nutritive tissue specialize along very different lines, especially do those on the funicular side become large and greatly elongated (*Fig. 16*).

FEMALE GAMETOPHYTE

The female gametophyte developes in the usual manner from the innermost of four megaspores that lie in linear series (*Fig. 3*). These are bounded externally by a thin nucellus consisting of a single layer of cells. Before the first division of the dominant megaspore the nucellus begins to break down at the tip (*Fig. 4*) and soon disappears entirely, leaving the naked female gametophyte protruding from the ovule (*Fig. 5*).

Meanwhile the single massive integument has arched over and pushed down parallel with the funiculus, and by the time the embryo-sac has reached the two-nucleate stage the integument touches the placenta at the base of the ovule (*Fig. 5*). But the female gametophyte, as noted above, has escaped confining structures at this end; it quickly makes contact with the placenta and begins digesting its way into this tissue (*Fig. 6*).

It follows, therefore, that no micropyle is really developed since the gametophyte, after the megaspore stage, is never completely enclosed. A pseudo-micropyle is formed with contact between integument and placenta, but sections at right angles show that the female gametophyte has lobes on either side reaching out into the ovarian chamber (*Fig. 9*). These protrusions of the embryo-sac are later encountered by the pollen tubes moving downward over the surface of the placenta among the ovules.

The embryo-sac at maturity is narrowly triangular in form (*Fig. 7*), the feeble antipodals occupying the narrower end. The egg and broad synergid cysts are anchored to the funicular side of the embryo-sac and are soon left far above its tip as the protoplasm pushes past the egg apparatus into the haustorium.

The polars meet a little above the egg, flatten together somewhat, and seem to remain in that relation until the pollen tube enters the ovule (*Fig. 7*). Proof of this is obtained from flowers in which only a part of the ovules have been fertilized. Intermixed with ovules containing embryos are others that failed to receive pollen tubes, and in these the polars are joined but not fused. Their union seems to be regularly completed, however, before the sperm reaches them.

The antipodals are never prominent and enter into early decline (*Fig. 7*). At maturity they are small and feebly staining nuclei that occupy the tip of the embryo-sac. With the entrance of the aggressive endosperm nuclei into this region they disappear entirely, so that the antipodal haustorium, later developed, is wholly an endosperm structure.

Cells of the ovary adjacent to the embryo-sac take on marked changes during its development and constitute the so-called "tapetum" of various authors. The cells elongate at right angles to the longer dimension of the embryo-sac, and in the outer part of the ovule are twice the diameter of the embryo-sac in length (*Fig. 9*). They seem to be equally prominent on the funicular and integument sides of the gametophyte.

MALE GAMETOPHYTE

The pollen grain measures 26x30 microns, and has its surface covered by a series of encrusted ridges giving it the appearance of a summer squash (*Fig. 15*). The microspores adhere in sticky masses, and in pollination by the visiting flies are rubbed off against the stigmatic hairs which line the inner surface of the upper lip of the stigma (*Fig. 1*). Upon germination the pollen tubes pass upward among the stigmatic hairs and enter the tissues of the upper lip of the stigma. From there they enter the back wall of the style and pass obliquely through it, following no fixed path until they enter the stylar canal.

The tubes strike the stylar canal at various heights above the ovary, and all seem ultimately to reach it, though some enter it very close to the base (*Fig. 1*).

The pollen tubes enter the ovary as a rope which quickly separates into its individual strands as the pollen tubes scatter among the ovules. The tubes are large and conspicuous, stain brilliantly, and so show conspicuously in sections. They creep along the placental surface where some of them encounter the protruding lobes of the female gametophyte (*Fig. 9*). This presents a type of conjugation unusual in Angiosperms; two naked protoplasmic masses come together outside the ovule when the pollen tube meets a lobe of the female gametophyte in the free space of the ovary.

The membrane investing the pollen tube seems to hold for some time after entering the female gametophyte, and all the evidence indicates that the tip of the tube follows its customary route to one of the synergids. In this instance the synergid is submerged within the cytoplasm of the embryo-sac and lies well towards the dorsal side, so that the pollen tube has to take a rather indirect course to reach it. The proof here is unusually strong that the synergid exercises a chemo-directive influence on the pollen tube, which in this instance could more easily have reached the egg directly. The gorged synergids stain brilliantly with safranin for some time, but the reaction grows fainter until by the time the embryo is well started the dilated synergid with the same stain appears as a grayish mass near the base of the suspensor. In *Polypompholyx* where similar conditions occur Lang (6) could not trace the pollen tube to the synergids.

The micropylar end of the embryo-sac often contains a large amount of material that seems to have come from supernumerary pollen tubes that possibly may have later discharged their contents into the embryo-sac (*Figs. 8, 9*). One of the writers (8) had previously noted in *Elodea* that the first and second tubes to enter the ovule terminated in the two synergids, and that if an additional tube entered, this discharged directly into the embryo-sac. In some cases all nuclei of the female gametophyte were obscured by this strongly staining mass that seemed to have come from the pollen tubes. This behavior is highly suggestive of the condition frequently observed in *Utricularia vulgaris.*

FERTILIZATION

Fertilization and secondary fertilization were noted in many ovules. The union of the sperm with the fusing polars is promptly achieved and the primary endosperm nucleus has usually passed to the telophase of its first division before the fusion of egg and sperm is completed. The whole series of events moreover moves rapidly. The upper ovules, nearer the place of exit of the pollen tubes from the stylar canal, have developed their first cells of endosperm before eggs in lower ovules have been fertilized. There is thus presented a wide range of stages in each ovary, though the distance from the top to base of placenta at this age is less than two millimeters. In other words, fertilization, double fertilization, and the first division of the primary endosperm nucleus may take place while the pollen tubes travel a distance of two millimeters. It might be, of course, that the earlier tubes are all taken by the upper ovules, but the method of pollination and the mass of pollen tubes implies excess numbers of tubes.

The cyst containing the fusing egg and sperm is generally more or less completely enwrapped by the gorged synergids, which are opaque with any protoplasmic stain (*Figs. 8, 9*). The second sperm uniting with the fused polars lies near the egg-cyst (*Fig. 8*), within the protoplasm of the embryo-sac.

THE ENDOSPERM

The primary endosperm nucleus divides soon after triple fusion and before egg and sperm have completely united (*Fig. 9*). Following this first division, a diaphragm is laid down across the embryo-sac separating the two daughter nuclei. The endosperm now displays great aggressiveness and with further divisions soon pushes its way out of both ends of the embryo-sac.

The innermost of the initial pair of endorperm nuclei divides repeatedly, with cleavage of the protoplast and development of cell walls (*Fig. 12*). The endosperm presses sharply into the antipodal end of the sac, and the tissue bordering this region soon disintegrates, so that presently two large endosperm cells come to lie side by side in a caecum protruding beyond the original limits of the embryo-sac (*Fig. 12*). Meanwhile the antipodal nuclei have disappeared entirely as the aggressive endosperm shoved past their original location.

The antipodal haustorium rapidly digests its way through all intervening cells and mushrooms out against the epidermis of the ovule (*Fig. 11*). The cells of this limited layer seem to be weakened under the attack, and the epidermis covering the haustorium becomes thinner than elsewhere. The epidermal cells of this region shrivel in preservatives and the riper seeds commonly show an opening through the outer investment at this point (*Fig. 10*).

The antipodal haustorium persists until the embryo is far advanced. It gradually flattens as the seed matures, and at a late stage shows only as a collapsed cap at the end of the embryo. Its nuclei become enormously enlarged, measuring 19x12 micra. Neither of its nuclei seems ever to divide.

It seems likely that the massive epidermis of these ovules functions both mechanically and to conduct materials. Its large cells show much starch, suggesting nutritive significance. The behavior of the antipodal haustorium might be explained as an attack on foods stored in the epidermis or being conducted through the cells of this layer.

MICROPYLAR HAUSTORIUM

The micropylar haustorium as noted above begins much earlier than the antipodal outgrowth, which is a post-fertilization development. The encroachment upon the tissue of the placenta noted above is launched by the protoplasm of the female gametophyte. Previous to fertilization it may have penetrated to a depth of two layers of cells, though no nuclei are thrown into the lobe at this stage (*Fig. 8*).

Early in the development of the endosperm two of its nuclei slide past the embryo and distended synergids, and enter this pouch (*Fig. 12*). Their arrival starts the second phase in the development of this haustorium, which then penetrates farther into the placenta and broadens into a rounded structure. A membrane for a time surrounds the haustorium, separating its protoplasm from the adjacent placental tissue (*Figs. 11-14*).

Digestion of the special receptive placental tissue continues until most of its walls have broken down, leaving a cavity filled with a coenocytic mass. Commonly a small volume of the receptive tissue is left on the funicular side with walls intact. With the disappearance of walls from this portion of the placental tissue the nuclei are set free in the common cytoplasm and present a wide range of sizes and shapes. They may enlarge somewhat, and apparently some of them unite to form tuber-like nuclei many times their normal size (*Fig. 14*).

Midway in the embryo development one or both of the endosperm nuclei of the micropylar haustorium may be seen apparently breaking through the limiting membrane. These endosperm nuclei, measuring 28x15 micra, are very different from those of the placental tissue being larger and having great splotches of darkly staining chromatin. They develop lobes which may in turn become dissociated amitotically into separate masses. These with the placental nuclei lying in the fluids of the haustorium, offer a most peculiar assemblage of nuclear structures (*Fig. 14*).

At a later stage the haustorium shrivels, leaving an empty pit in the placenta and also a companion cavity in the base of the seed. As suggested by Merz (7) the endosperm adjacent to the haustorium forms a plug which closes this opening into the seed. The placenta, after seeds are shed, is pitted all over its surface, marking the positions of the haustoria.

The endosperm about the seed offers no peculiarities. It forms a spindle-shaped mass which entirely surrounds the embryo except at the base of the long and slender suspensor, which remains until late in the development anchored to the funicular wall of the embryo-sac.

THE MATURE SEED

During later development of the embryo the seeds are pressed together in a compact layer between placenta and ovary wall. Under dissection of living material it was noted that the seeds are much more firmly united to each other than to the placenta, and the whole cap of seeds might be lifted off like a ripe raspberry. This only confirms their dependence upon the micropylar haustorium for nutrition and their practical abandonment of funicular connection with the ovary.

DISCUSSION

In the introduction to this paper brief reference was made to the general uniformity of events transpiring within the embryo-sac of the Angiosperm. In *Utricularia* the relation of the ovules to adjacent parts is such as to make possible departures from the typical story, and morphological investigations reveal unusual behavior of both the female gametophyte and the endosperm. While these pecularities differ only in degree from many others frequently noted elsewhere, their prominent expression in this plant is made possible through the relations here existing between ovule, placenta, and ovary wall. Had not the developing seeds been held firmly in place, independent of their own attachments, there could have been no micropylar haustorium of such pronounced type. Under usual conditions such outgrowths are impossible, and even their initiation is generally inhibited.

In considering departures from the typical embryo-sac story these haustorial developments, either micropylar or antipodal, constitute those most frequently encountered. They have generally been interpreted, and probably correctly, as nutritive devices of one sort or another. In the large, they represent efforts on the part of the contained embryo-sac nuclei to express themselves in more marked way than is typically the case. While most of these emergent structures are abortive, some of them proliferate considerable distances through contiguous tissues and constitute striking outgrowths from the embryo-sac.

Without summarizing here the extensive and well known literature on this subject, one might cite typical papers in this field. Billings (2, 3) has made a careful study of nutritive outgrowths from embryo-sacs, particularly in the Labiatæ, and his figures reveal a striking series in this group; Chamberlain (4) found unusual development of the antipodals in certain of the Compositae; Balicka-Iwanowska (1) investigated numerous of the Scrophulariaceæ, recording several cases comparable to that found in *Utricularia,* particularly in *Scrophularia vernalis* which has both micropylar and antipodal outgrowths; while Merz (7) and Kamienski (5) worked on various species of *Utricularia,* outlining quite fully the story discussed in detail above. Of special interest is the paper by Lang (6), which resulted in shifting *Polypompholyx* and *Byblis* from the Droseraceæ to the Lentibulariaceæ. Many of the figures of *Polypompholyx* in this paper are very similar to conditions found in *Utricularia vulgaris.*

Antipodal outgrowths may be quite large, especially in the case of those ovules with massive integument, and some of them may attain to remarkable length and complexity. The antipodal region borders on a mass of tissue, merging into the funiculus, and makes connection quite directly with the major vascular supply of the ovule. This invites specialization in this direction and the question might well be considered as to why such haustoria are not more common and more highly specialized than they seem to be. In *Utricularia* the antipodal haustorium is post-fertilization in development and is purely an endosperm outgrowth, seemingly to tap the foods stored or transported in the epidermis of the ovule. Its importance diminishes relatively as embryo development proceeds, its work being supplemented and later supplanted by the haustorium at the opposite end of the ovule.

In the closely related *Polypompholyx,* Lang (6), finds that the female gametophyte begins an antipodal haustorium which, as in the case of *Utricularia,* is later markedly developed by the endosperm, two cells of which dominate its growth. In *Polypompholyx,* however, there is developed an extensive nutritive tissue into which the haustorium enters so that it does not reach the epidermis of the ovule. The antipodal haustorium in this form is larger and functions longer than in *Utricularia.*

While micropylar haustoria are not uncommon, these in general are smaller and less highly specialized. The explanation for their failure is not far to seek, since it follows from the relations of the embryo-sac to adjacent parts in this direction.

The micropylar haustorium, in contrast to that of the antipodal end, usually finds no receptive tissue before it, so there is little to encourage prolongation in that direction. Outside the thin zone of the nucellus lies the sterile micropyle or the fused integuments. Only in the case of anatropous ovules is there nutritive invitation beyond the integument, where further elongation might tap the placental tissues. Mere inversion of the ovule is not sufficient, however, to insure suitable conditions for the development of a haustorium at the micropylar end. It is important that there be contact with the placenta so that any protruding part may not enter a space system if extended beyond the micropyle. Further, there must be no serious growth movements, preliminary to, or especially after fertilization to alter the relations of these adjacent parts which are merely pressed together and are not organically connected.

Utricularia offers favorable opportunity, therefore, for basilar outgrowth from the embryo-sac, and both the female gametophyte and the endosperm participate in its development. After mid phase in embryo development it seems to be the only channel for transfer of food to the ovule.

There is no development of vascular tissue in the funiculus, which gradually is subordinated until later it becomes a mere rudiment. The seeds are scarcely attached as they approach maturity, and may be lifted off from the receptacle in a cohering layer, so feebly do their funiculi support them.

Utricularia thus presents an anomalous situation in that the embryo is nourished throughout its development by haustorial outgrowths. The fact that the developing seeds are held firmly in place between ovary wall and placenta, while lateral displacement is prevented by mutual pressure of the ovules, permits diminished emphasis upon funicular attachment and favors direct transfer of materials by means of the micropylar haustorium. The not infrequent abortions are probably due to displacement of ovules thus severing the soft suctorial organs. In any event the specializations here noted suggest that with greater liberty the female gametophyte and endosperm might offer in general greater variety of form and behavior.

Such views are fortified by comparison of *Utricularia* with conditions reported in *Polypompolyx* by Lang (6). Developments are similar except that the receptive tissue into which the micropylar haustorium enters is located in a hump on the funiculus of the ovule instead of in the placenta. The outgrowth is dominated by the endosperm and it displays characters similar to that described above for the Bladderwort, except that it never attains the prominence shown in *Utricularia,* and is less conspicuous than the antipodal haustorium of the same ovule. Since both masses of receptive tissue are within the ovule in *Polypompholyx,* it must use its funiculus in the regular way and so is debarred from the unusual achievement of *Utricularia* which attacks the placenta directly.

The writers of this paper would like to emphasize the view that events taking place within the pistil of the Angiosperm are so closely inter-dependent that these relations dominate the gametophytes. They prevent, on one hand, enlargement of the female gametophyte in any such degree as marks the Gymnosperms, since fertilization is not long delayed. Perhaps these same conditions also operate in some way to inhibit reduction of the embryo-sac to the theoretically possible limit of a single egg, by demanding coöperating cells and nuclei. The male gametophyte, as represented by the pollen tube, presents a similarly specialized mechanism. It must, with the female gametophyte, follow a precise program involving both time and space relations which permit of limited variation.

In other words, the make up of the ovule and its contents in relation to the pollen tube habit outweighs all other factors and invites to a peculiar type of specialization. The limitations imposed by the associated parts are very definite, and despite the most marked contrasts in size, habitat, floral and vegetative development, as well as divergent kinship between the various groups of Angiosperms, the behavior of the male and female gametophytes displays a remarkable uniformity. This constancy then represents a survival of structures and habits best fitted to the exacting type of siphonogamy found in this great group, rather than a stage of incomplete reduction or evolution.

SUMMARY

1. The inverted ovules of *Utricularia vulgaris* are crowded

together on a free central placenta and are tightly invested by the ovary wall.

2. The female gametophyte, arising from the innermost megaspore, early digests the nucellus and protrudes from the ovule. It is never enclosed by the integument.

3. This micropylar haustorium invades the tissue of the placenta which in anticipation of such intrusion has developed a mass of nutritive tissue opposite the micropyle of the ovule.

4. The pollen tubes creeping down over the surface of the placenta encounter the protruding lobes of the female gametophyte, and pass through their cytoplasm to the synergids.

5. Fertilization and double fertilization take place in practically all of the ovules, few aborting at this early stage. The primary endosperm nucleus divides before union of egg and sperm is completed.

6. The antipodals are very small and inconspicuous, and disappear soon after fertilization.

7. The endosperm early in its development pushes two cells past the feeble antipodals and develops a haustorium which penetrates to the epidermis of the ovule against which it flattens out. It persists until the seed is nearly mature and seems to take food from the heavy epidermal layer of the ovule.

8. Similarly two endosperm nuclei pass by the egg apparatus and enter the micropylar haustorium, which then energetically attacks the receptive tissue of the placenta.

9. The funiculus of the ovule does not develop after fertilization, and rapid growth of other parts leaves it as a rudimentary structure which remains without vascular tissue and becomes practically functionless.

10. Within the dome shaped placenta vascular strands are freely developed with branches which end near the bases of the ovules. Each strand is directed towards the base of a funiculus, but terminates alongside the mass of "receptive" tissue.

11. The micropylar haustorium remains prominent during seed development, digests most of the receptive tissue, and becomes the medium through which food is transferred to the embryo. Adjacent cells of the placenta are elongated radially and seem to conduct food to the haustorium.

12. The seeds during later development are practically with-

out attachment and are held in place by the pressure of surrounding parts,—the placenta, ovary wall and adjacent ovules, —and each is nourished directly by means of its micropylar absorbing organ.

13. Their unusual behavior in *Utricularia* and similar forms suggests that the female gametophyte and endosperm, if given favorable opportunity, may assume more marked development than is typically displayed.

14. It seems probable that the constancy of events within the ovule of the Angiosperm is correlated with its structure and the type of siphonogamy found in this group. The gametophytes must follow a precise program and post-fertilization activities are under ordinary conditions largely under the control of the ovule.

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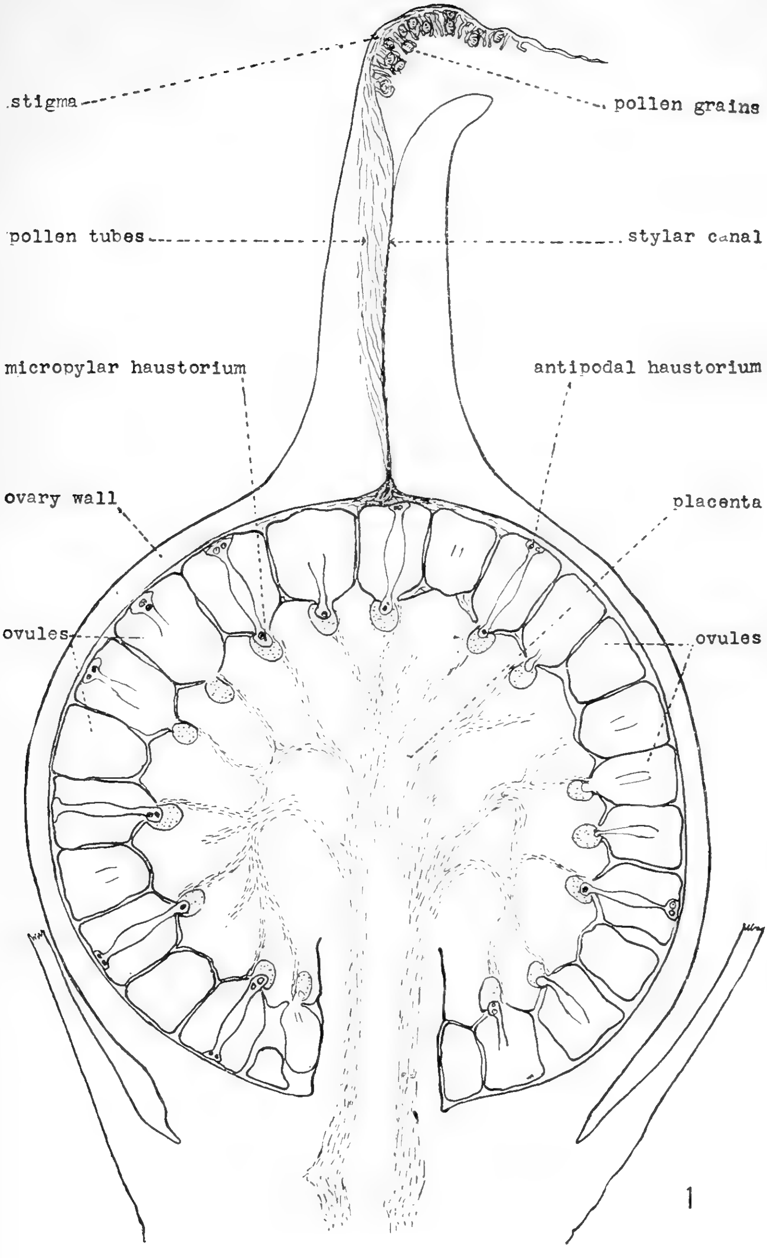
PLATE I



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DESCRIPTION OF PLATES

The following abbreviations are used:
a, receptive portion of placenta; *b*, antipodal haustorium; *c*, embryo; *e*, endosperm; *f*, micropylar haustorium; *g*, egg; *h*, polars; *j*, antipodals; *k*, synergid; *m*, nuclei of micropylar haustorium; *n*, integument; *o*, funiculus; *t*, pollen tube; *v*, placenta; *x*, sperm

PLATE I

Fig. 1. Longitudinal section through pistil showing relative size and arrangement of parts soon after fertilization

PLATE II

Fig. 2. Early stage showing spore-mother-cell, and outlining below the "receptive" portion of the placenta later to receive the basilar haustorium

Fig. 3. Stage showing the four megaspores

Fig. 4. Dominant megaspore with other megaspores and nucellar tissue breaking down

Fig. 5. Two-celled gametophyte; nucellus digested, and micropylar haustorium entering placenta

Fig. 6. Early post-fertilization, showing two-celled endosperm, micropylar haustorium, and receptive tissue

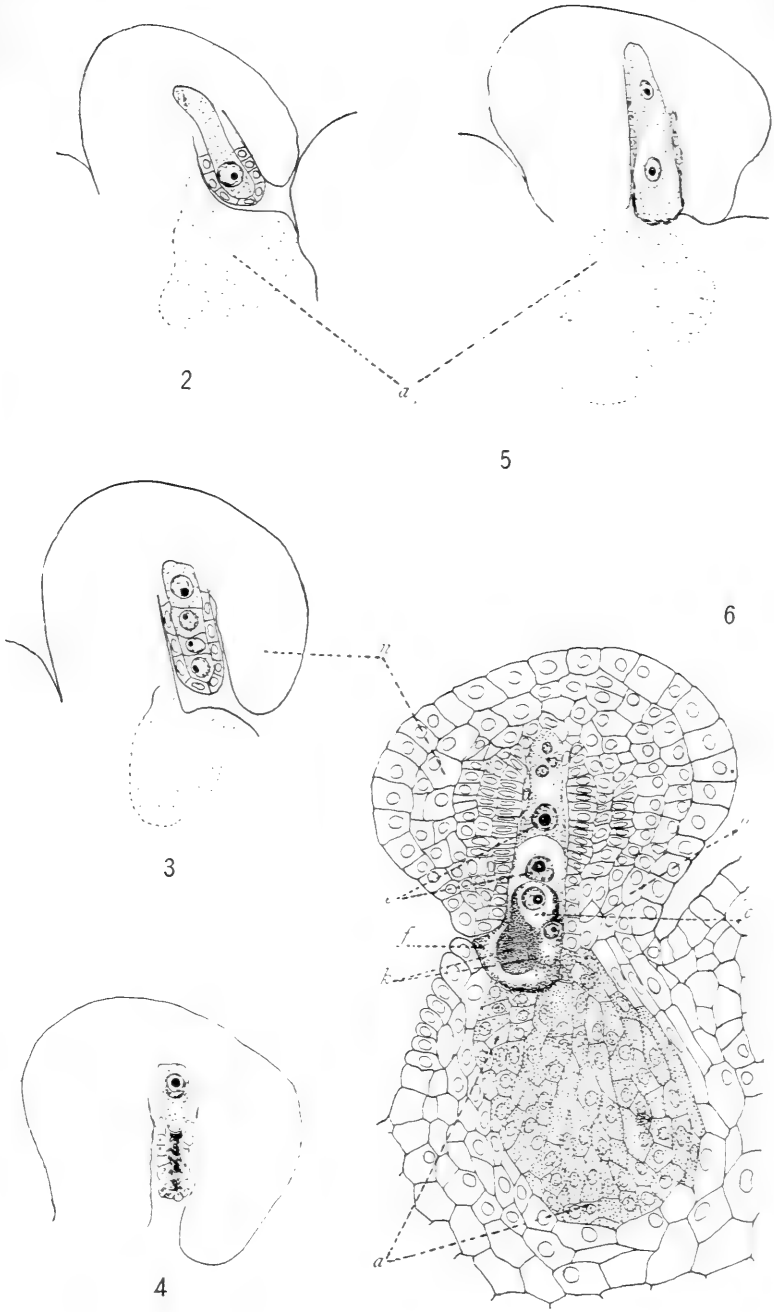

2
a
5
3
n
6
n
c
f
k
c
a
4

PLATE III

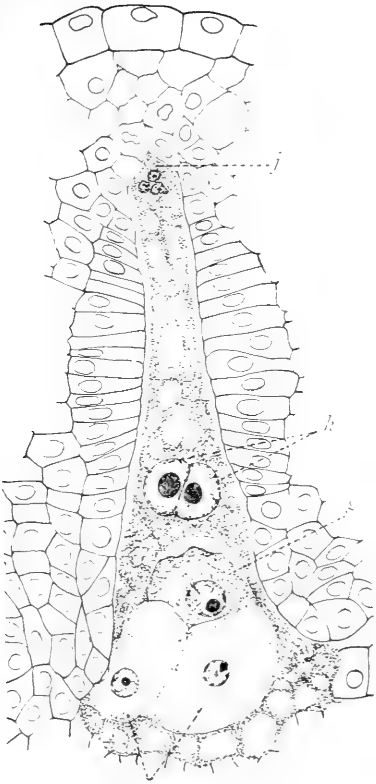
Fig. 7. Mature female gametophyte

Fig. 8. Fertilization and double fertilization; synergid gorged with pollen tube contents

Fig. 9. Pollen tube joined to lobe of the micropylar haustorium; primary endosperm nucleus dividing

Fig. 10. Mature seed, showing its angled form due to pressure during development

PLATE III



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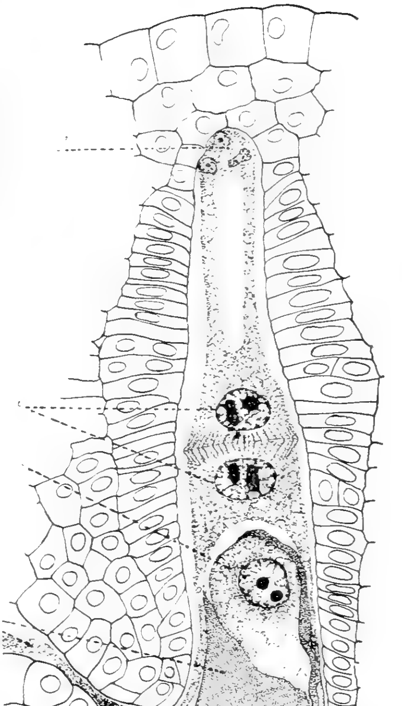

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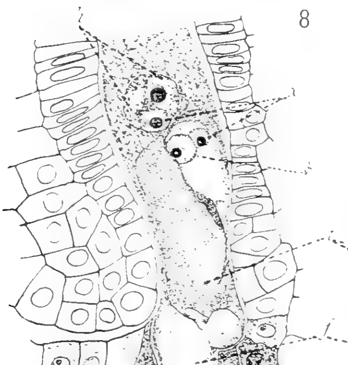

PLATE IV

Fig. 11. Longitudinal section through ovule showing embryo, haustoria, receptive tissue, and diminutive funiculus

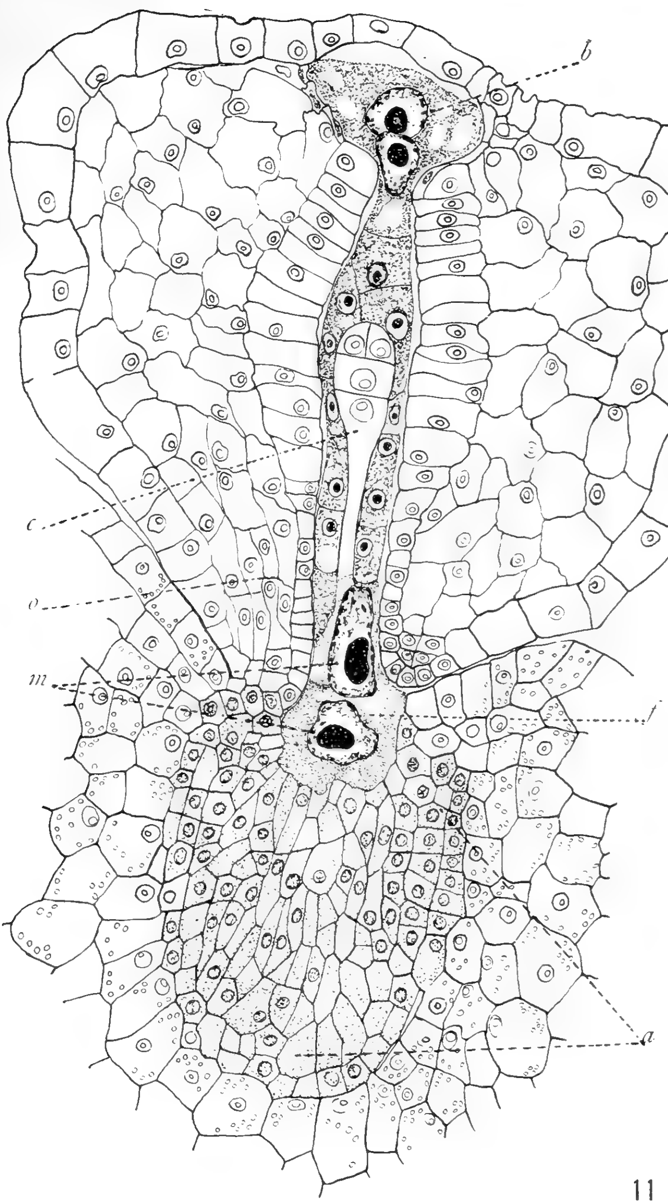

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PLATE V

Fig. 12. Slightly younger stage than the preceding, with antipodal haustorium relatively farther advanced than the basilar outgrowth

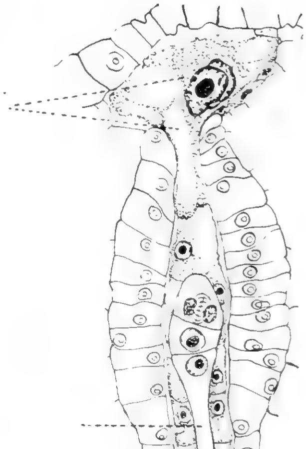
Fig. 13. Showing invasion of the receptive tissue by the micropylar haustorium with its prominent endosperm nuclei

Fig. 14. Later stage in which the cell walls have disappeared from the receptive tissue, and showing the peculiar nuclei lying in the cavity; the endosperm nuclei are the more darkly staining

Fig. 15. Pollen grain

PLATE V

15



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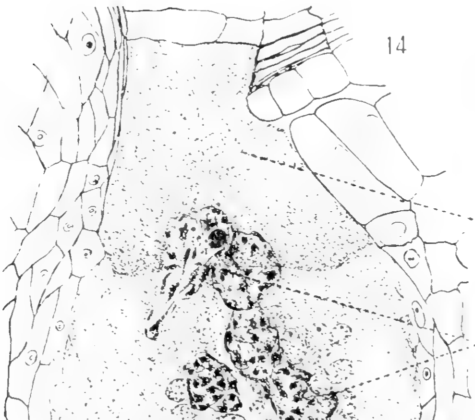
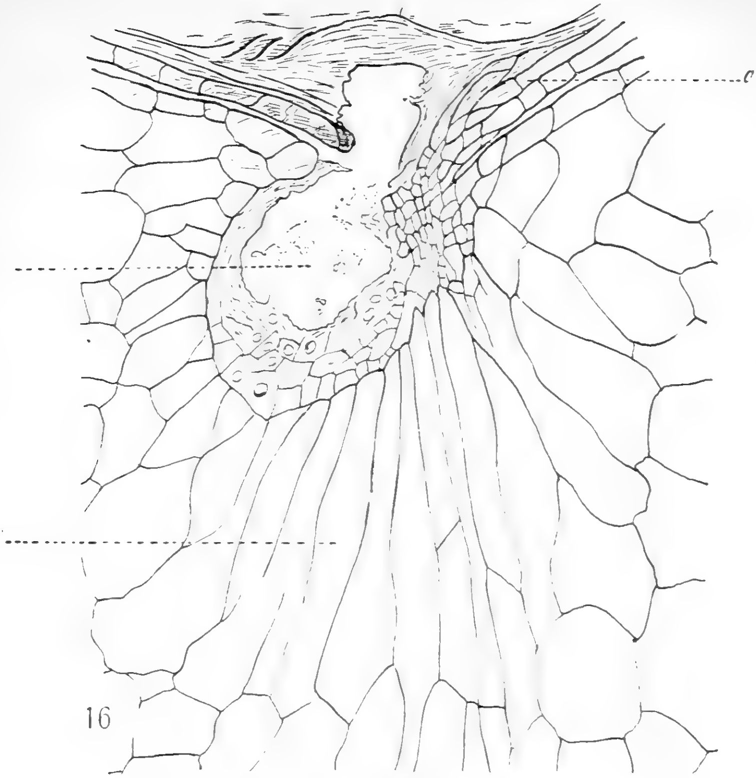


PLATE VI

Fig. 16. Placental tissue near base of a nearly ripe seed

Fig. 17. Showing arrangement of the seeds covering the central placenta, after ovary wall has been removed

PLATE VI



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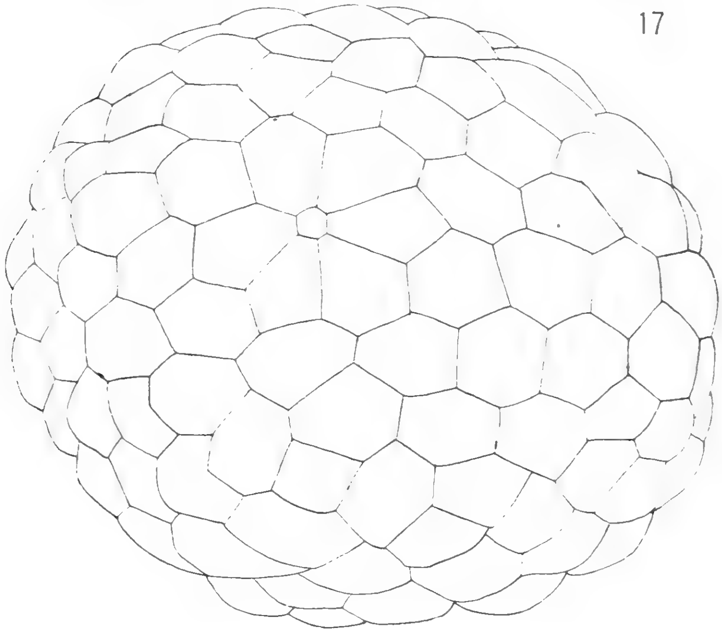

THE AMPHIBIANS AND REPTILES OF DICKINSON COUNTY, IOWA

By Frank N. Blanchard

Department of Zoology, University of Michigan

The period from June 22 to July 31, 1920, was spent by the writer at the Iowa Lakeside Laboratory on Lake Okoboji in Dickinson County, northwestern Iowa, for the purpose of collecting a representative series for the Museum of Zoology of the University of Michigan. Collecting was done in the townships of Lakeville, Spirit Lake, Center Grove, Okoboji, and Diamond Lake.

For their many kindnesses throughout his study, the writer wishes to express his deep appreciation to Professor Robert B. Wylie, Director of the Lakeside Laboratory, and to Professor Frank A. Stromsten of the Department of Zoology of the University of Iowa.

The region is one of terminal moraine topography, dating from the last, or Wisconsin, ice sheet. The central portion of the county is the lake region of Iowa. Here are the three large lakes, East and West Okoboji and Spirit Lakes, besides many smaller ones of all sizes. West of the lakes, and flowing in general from north to south, lies the Little Sioux River, a tributary of the Missouri. The steeper shores of the lakes and of the Little Sioux are generally covered with trees, sometimes pure stands of bur oak (*Quercus macrocarpa*), at other times bur oak accompanied by basswood, ash and elm, but in all other places a natural growth of trees is lacking. Undrained depressions, or sloughs, of all sizes are common everywhere, but their number is being fast diminished by the digging of ditches and the placing of tile drains. Nearly all of the land is either under cultivation or devoted to pasturage, but occasional fields of unaltered prairie and natural woodland still remain. Their number and area are however so small that vertebrate forms dependent upon natural conditions for their existence have been

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Contributions from the Iowa Lakeside Laboratory, No. 50

nearly or quite exterminated. It is highly important that faunistic studies be undertaken here, and throughout our country, at as early a date as possible if we are to have any record of the composition and distribution of our native fauna, and if we are to deal intelligently with its preservation. For an excellent account of the vegetation of the region see Shimek, 1915, and for a discussion of prairie habitats applicable to this locality, see Ruthven, 1910.

The present study shows the natural reptile-amphibian fauna to be rather poor in number of forms, and to be rapidly growing much poorer. Even those species that find the region naturally highly favorable are maintaining a losing struggle against cultivation of the land and persecution.

As already pointed out by Ruthven (1910, 202) the reptile-amphibian fauna is made up of both eastern and western forms. Those characteristic of the eastern forests are, as would be expected, but scantily represented. There is definite record for only one forest amphibian, *Hyla versicolor versicolor*. Of snakes preferring the forests, *Storeria occipito-maculata* is rare here, and *Diadophis arnyi* has been taken in Plymouth County and may yet be found in this vicinity. *Thamnophis sirtalis parietalis* appears to have greater preference for the woods than for the open prairies, and is moderately common. As is well known, its close relative, *T. sirtalis sirtalis,* has found the eastern deciduous forest region a highly favorable habitat.

Eastern aquatic and land forms are represented by *Bufo americanus, Acris gryllus, Rana pipiens,* and *Liopeltis vernalis* (the latter not yet on record for this county but undoubtedly present.)

Of strictly western forms there are *Pleistodon septentrionalis, Chrysemys marginata bellii, Thamnophis radix, Heterodon nasicus,* and three which doubtless occur here but have not yet been taken, *Pituophis sayi, Lampropeltis triangulum syspila* and *Sistrurus catenatus catenatus.*

For several species of snakes this region appears to be close to, or just beyond, the northern limit of their distribution. It is probable that *Liopeltis vernalis, Diadophis arnyi, Elaphe vulpina, Pituophis sayi,* and *Lampropeltis triangulum syspila,* will yet be found in the county, while the following forms, well-known from a little farther south, are not expected: *Coluber constrictor flaviventris, Lampropeltis getulus holbrooki, Storeria dekayi, Thamnophis proximus,* and *Natrix sipedon sipedon.*

The following amphibians and reptiles were taken by the writer (unless otherwise stated) in 1920 in Dickinson County, Iowa, and are deposited in the Museum of Zoology of the University of Michigan at Ann Arbor.

Necturus maculosus (Rafinesque).—Mud Puppy.—One specimen was seined from a pond near Hottes Lake in Spirit Lake Township on August 7 by Drs. Kuntz and Thomas. This specimen was shipped to me by Professor Stromsten who declares there can be no doubt about its being a *Necturus,* but was spoiled and destroyed before I was able to see it. It is probable that another specimen was taken in the outlet from Spirit Lake a year earlier, but this also was eventually lost.

Ambystoma tigrinum (Green).—Tiger Salamander.—Common throughout the region. One adult was taken in a damp cess-pool on the Laboratory grounds on July 5. Larvae in all stages were plentiful in several of the small ponds in pastures and fields, and at least one specimen was found in nearly every pond seined. In a very small pasture pond by the side of the road north of the Laboratory 160 specimens were taken with a seine in less than an hour. In this as in other ponds where they were common, they were found to be much more plentiful towards the center of the pond, away from grass and algae.

Bufo americanus Holbrook.—American Toad.—Common but not abundant in the county. Eight adults were taken, four near the Laboratory, one on the north shore of West Lake Okoboji, one on the shore of Upper Gar Lake, and two on the banks of the Little Sioux River. Young individuals were found transforming in a marsh near the shore of East Lake Okoboji on July 8, and several others, about a centimeter and a half in length, on the grassy mud-flats of Lower Gar Lake on July 17.

Pseudacris triseriata (Wied).—Swamp Tree Frog.—Two adults were found, one on a rainy day, July 7, in the tall grass of a wet meadow between Miller's and Emerson's Bays, West Lake Okoboji, and the other in the sparse undergrowth of an oak woods between Robinson and Marble Lakes in Spirit Lake Township on July 15. In one specimen the heel when extended forward reaches the anterior border of the tympanum; in the other the posterior border.

Hyla versicolor versicolor Le Conte.—Tree Frog.—A single adult was found under the loose dry bark of a dead oak in the dense woods along the Little Sioux River in Okoboji Township, June 20. Five young ones, four with tails and one without, were found while seining a woods pond covered with duckweed between Marble and Hottes Lakes in Spirit Lake Township on July 28. Other records for this county are: Center Lake region, July 22, 1918, and Lake Okoboji, July 1914, T. C. Stephens (Ruthven, 1919, 2).

Acris gryllus (Le Conte).—Cricket Frog.—Common but not abundant. It was found in nearly all suitable localities; the muddy shores of the Little Sioux River in Okoboji and Lakeville Townships, open shores along the canal and on Miller's Bay in Lakeville Township, open borders of small ponds or sloughs, and along Lower Gar Lake in Center Grove Township.

Rana pipiens Schreber.—Leopard Frog.—This is the widespread and abundant amphibian of the region. Specimens were taken in all the townships visited. It occurs near all the lakes, sloughs, and streams, and is common in tall, and sometimes in short grass, on the prairies and uplands far from water. It is rare, however, in the woods. Young frogs, just metamorphosed, were exceedingly numerous on July 14 and 15 in Spirit Lake Township, between Marble and Hottes Lakes, near their breeding ponds, but even two weeks later tadpoles with only the hind legs developed were still plentiful in the ponds. Several individuals, both young and old adults, were found with no spots on the body and those of the legs much reduced.

Plestiodon septentrionalis Baird.—Skink.—Not common. A single specimen was taken on the Laboratory grounds on June 25. It was first found on Lake Okoboji by Dr. T. C. Stephens in July, 1914.

Heterodon nasicus Baird & Girard.—Western Hog-nosed Snake; Spreading Adder; Blow-Snake.—Apparently rare in the county. One specimen was found by Professor Stromsten, on

July 23, on the bank of the Little Sioux, where the river flows through a pasture two miles west of the Laboratory.

Its description is as follows: Ventrals, 145; caudals, 37; upper labials, 8; lower labials, 10; dorsal scale formula, 23-21-19; 40 dorsal spots on body, 11 on tail; two rows of lateral spots; total length, 594 mm., tail length, 88 mm., tail divided by total length, .148; accessory scales separating the two prefrontals, the prefrontal from the frontal, and the internasals from the rostral; female.

Storeria occipito-maculata (Storer)—Red-bellied Snake.—This snake is occasionally seen in the county. A specimen was taken at Lake Okoboji, June 20, 1917, by Dr. T. C. Stephens.

Thamnophis sirtalis parietalis Say.—Red-sided Garter Snake.—Common, but much less so than *T. radix.* Eight specimens, representing the townships of Lakeville, Okoboji, Center Grove, and Spirit Lake, were secured and these were all found not far from woods.

Thamnophis radix (Baird and Girard).—Common Garter Snake.—This is the common land reptile of the region. It was found in all the townships and in all habitats visited. It was, however, only rarely met with in the woods, but on the prairie in tall or short grass, along fences and roadsides, near marshes, sloughs, and lake shores, it is frequently seen. It will readily take to water when disturbed along the shore of a pond, and one young individual was met with at least a hundred feet from the shore of Miller's Bay, swimming toward the open lake.

Chelydra serpentina (Linné). Snapping Turtle.—Common in all the lakes, sloughs, and rivers in the region. Specimens obtained represent Lakeville, Center Grove, and Spirit Lake Townships. A nest containing nineteen eggs was found near the lake shore in the field north of the Laboratory on July 1, by Professor F. A. Stromsten. The nest had been opened by some animal and two or three eggs taken out and destroyed. It was very fresh, perhaps not more than a day old. A specimen found killed on the shore of Hottes Lake had a carapace 38 centimeters long.

Emys blandingii (Holbrook).—A large female of this species was captured in a bayou of the Little Sioux River directly west of the town of Spirit Lake, and was given by Mr. Frank P. Hopkins of the boat-landing at Spirit Lake to Professor Keyes of the Lakeside Laboratory in the summer of 1921. The specimen was sent to the writer by Professor Stromsten. Its carapace is approximately 23 cm. long, and 15.5 cm. in greatest width, and the turtle is about 10 cm. high. This appears to be the most western point recorded for this species, and the first record for Iowa.

Terrapene ornata (Agassiz).—Box Turtle.—Professor Stromsten reports finding, in a ravine near the Laboratory, a box turtle which he referred to this species. It was found August 17, 1916, dissected and destroyed. As Professor Stromsten could hardly mistake a box tortoise, his report deserves consideration. However, this form is undoubtedly very rare in the region.

Chrysemys marginata bellii (Gray).—Bell's Painted Turtle.—Abundant in all lakes, sloughs, and rivers in the region. One turtle was discovered completing nest building on the grassy lawn in front of the Laboratory on June 26, about an hour or more before sunset. Thirteen eggs were dug from the nest. Another turtle was found completing its nest at the edge of the pasture north of the Laboratory about ten feet from the lake shore. This nest contained twelve eggs. In each case the earth about and over the eggs was well wetted. Another nest found a few days later very near this one contained eleven eggs. Near the small lakes west of Spirit Lake seven apparently complete sets of eggs were recovered containing, respectively, 5, 6, 6, 7, 7, 9, and 12 eggs. Many nests were discovered pilfered by some animal, with all of the eggs destroyed and the shells scattered about in the vicinity .

Amyda spinifera (LeSueur).—Soft Shelled Turtle.—Evidently common in the Little Sioux River. One adult was taken in the Township of Okoboji on the bank of the Little Sioux on July 3 in the middle of the afternoon. It was beginning to prepare a nest about twelve feet from the water on a sunny bank, sloping at an angle of about 30 degrees. The impression of the body on the ground showed that the turtle was facing the river, and that the two hind feet were used in digging the double burrow. The latter was already well under way, as it was 4 inches in greatest length and from 1½ to 2 inches deep.

KEY TO ADULT AMPHIBIANS (SALAMANDERS, FROGS, AND TOADS) LIKELY TO BE FOUND IN DICKINSON COUNTY, IOWA

a1. Tail present; hind legs not elongated for jumping.
  b1. Four toes on hind foot; external gills present throughout life............ *Necturus maculosus* (Rafinesque).
  b2. Five toes on hind foot; no external gills on adult; dark brown or black, variously spotted with yellow. *Ambystoma tigrinum* (Green).
a2. Tail absent; hind legs elongated for jumping.
  c1. Skin dry and warty.. *Bufo americanus* Holbrook.
  c2. Skin moist and not warty.
    d1. A pair of dorso-lateral ridges; no sucking disks on toes. Back with roundish black spots edged with white.. *Rana pipiens* Schreber.
    d2 No dorso-lateral ridges; sucking disks on toes present, even if small.
      e1. Belly smooth; upper surfaces somewhat roughened; snout pointed; sucking disks minute; size 1 to 1 1-4 inches............ *Acris Gryllus* (Le Conte).
      e2. Belly granular; upper surfaces smooth.
        f1. Sucking disks large; a broad whitish band from eye to angle of mouth; size over 1 inch. *Hyla versicolor versicolor* Le Conte.
        f2. Sucking disks minute; no broad band from eye to angle of mouth; on sides of body two dark bands separated by a lighter one, the lower band passing forward through the eye to the snout *Pseudacris triseriata* (Wied).

KEY TO REPTILES (LIZARDS, SNAKES, AND TURTLES) LIKELY TO BE FOUND IN DICKINSON COUNTY, IOWA

a1. Legs present.
  b1. No broad dorsal shield; body elongate, covered with smooth scales throughout.. *Pleistodon septentrionalis* Baird.
  b2. A broad dorsal shield, or carapace, present; body short and broad.
    c1. Carapace flexible at the edges.
      d1. Front margin of carapace with conical tubercles........................ *Amyda spinifera* (LeSueur).
      d2. Front margin of carapace smooth....... *Amyda mutica* (LeSueur).
    c2. Carapace not flexible at the edges.
      e1. Ventral shield, or plastron, very narrow, exposing the soft parts.. *Chelydra serpentina* (Linné).
      e2. Ventral shield or plastron broad.
        f1. Parts of plastron immovably attached to each other and to carapace; throat with black stripes.. *Chrysemys marginata bellii* (Gray).
        f2. Plastron with a transverse hinge, and movably attached to carapace, throat yellow without black stripes.
          ff1. Upper jaw notched in front; carapace long and depressed *Emys blandingii* (Holbrook).
          ff2. Upper jaw produced downward at symphysis to form a hook; carapace short and high.. *Terrapene ornata* (Agassiz).
a2. Legs absent.
  g1. No anterior fangs in upper jaw; no rattle on end of tail.
    h1. Anal plate entire (i. e. not divided).

i[1]. Body scales smooth (i. e. without median keels). Body with broad dorsal blotches of red bordered with black and separated by bands of whitish or yellow.
Lampropeltis triangulum syspila (Cope).

i[2]. Body scales each with a median lengthwise keel.

j[1]. Body scales in 27 to 33 rows; rostral plate conspicuously enlarged and partially separating the two scales behind it; pattern of many large spots............*Pituophis sayi* (Schlegel).

j[2]. Body scales in 19 to 21 rows; rostral normal; pattern of lengthwise stripes.

k[1]. Lateral stripe extending upon the fourth row of dorsal scales anteriorly (counting from the belly); scales in 21 rows..................*Thamnophis radix* (Baird & Girard).

k[2]. Lateral stripe not extending upon the fourth row of dorsal scales anteriorly; dorsal scales in 19 rows..............
Thamnophis sirtalis parietalis (Say).

h[2]. Anal plate divided.

l[1]. Dorsal scales keeled.

m[1]. Rostral normal,—not enlarged and recurved; body slender.

n[1]. Scales in 25 to 27 rows, only faintly keeled; pattern of large spots; size large......*Elaphe vulpina* (Baird & Girard).

n[2]. Scales in 15 to 17 rows, distinctly keeled; pattern not of large spots; size small.

o[1]. Scales in 17 rows; a single scale in front of the eye; belly whitish....................*Storeria dekayi* (Holbrook).

o[2]. Scales in 15 rows; two small scales in front of the eye; belly reddish..........*Storeria occipito-maculata* (Storer).

m[2]. Rostral enlarged and recurved; body stout....................
Heterodon nasicus Baird & Girard.

l[2]. Dorsal scales smooth (not keeled).

p[1]. Dorsal scales in 15 rows; bright green above, belly light, unspotted............................*Liopeltis vernalis* (Harlan).

p[2]. Dorsal scales in 17 rows; ashy to brownish black above, belly yellow or reddish with small black spots....................
Diadophis punctatus arnyi (Kennicott).

g[2]. Anterior fangs present in upper jaw; rattle on end of tail; large plates on top of head *Sistrurus catenatus catenatus* (Rafinesque).

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THE LEARNING OF A SIMPLE MAZE BY THE LARVA OF AMBYSTOMA TIGRINUM (GREEN)

By Albert Kuntz
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One of the methods commonly employed in the study of the behavior of lower vertebrates in attempts to determine whether they possess associative memory, or the capacity to learn by repeated experience, involves setting before them simple tasks which they are able to accomplish without too great effort, providing the proper stimulus, and noting the time and effort required to accomplish the tasks in repeated trials. One of the most convenient devices for this purpose is a simple maze; i. e., a more or less tortuous path along which the animal may be induced to travel. If it has associative memory it will be able to reach a given objective in such a path in less time and with less effort after the task has been accomplished repeatedly than in the initial trial. It will also be able to retain the simple habit thus acquired.

Studies of this character on fish carried out by Triplett (1901), Thorndike (1911), Goldsmith (1914), and Churchill (1916) indicate that these animals are capable of forming simple habits which they retain for some time. Studies on the behavior of Batrachians by Abbott (1894) led him to conclude that the "wits of the frog were too limited to be demonstrated." On the other hand, experimental studies on the behavior of frogs and toads by Knauer (1875), Jourdain (1900), and Yerkes (1903) indicate that these animals are capable of forming simple associations and of acquiring simple habits which may be retained for relatively long intervals of time.

Although the Amphibian brain represents a higher degree of organization than the fish brain, the nervous mechanism of Amphibia like *Ambystoma*, by reason of their mode of life, is less constantly and less intensely stimulated by the environment than that of the fish. Being cryptic in their habits their survival

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depends less on their capacity to escape their enemies by immediate effort than on the protection afforded by the environment. Consequently there is *a priori* no ground for the assumption that these animals possess associative memory or the capacity to learn by repeated experience to a greater degree than certain of the fish, even though the latter possess a relatively less complex nervous mechanism.

Neither is there any ground for the assumption that the Urodela and Anura possess associative memory in like degree. Furthermore, the animals used in this study had not yet attained their adult condition. Consequently, direct comparison of their achievements with those of the animals used in the studies referred to above would have little significance.

One of the most important factors in studies of this character is the stimulus employed. It must be one which will insure more or less continuous effort on the part of the animal until the object is reached. Some of the lower vertebrates, when hungry, are stimulated strongly by the presence of food. Such animals, under proper conditions, make a more or less continuous effort to find the way through a simple maze in order to secure food. In such cases food is a very satisfactory stimulus. The larvae of *Ambystoma* are not sufficiently strongly stimulated by the presence of food, even when hungry, to insure a sustained effort to secure it. However, they react strongly to intense light. When exposed to direct sunlight they seek any available shaded area. They are not always as persistent in their efforts to escape the direct rays of the sun as the experimenter might wish. Nevertheless, direct sunlight probably is the best stimulus available for studies of this character on the larvae of *Ambystoma*.

A simple maze (fig. 1), similar to those used by Thorndike and Churchill, was arranged in an aquarium (62x21x23 cm.) with metal walls. In the bottom of the aquarium was a bed of sand approximately 4 cm. in depth. The water over the sand was approximately 6 cm. in depth. The aquarium was placed in direct sunlight so that the entire area of the water except that which fell within the shadow of the end wall toward the sun was exposed to the sun's rays.

Animals which react negatively to intense light commonly retreat from the source of the light. In order to determine whether the larvae of *Ambystoma* would find the shaded area at the end of the aquarium toward the sun as readily as they would a shaded area at the opposite end, individual animals were placed in a transverse position at the center of the aquarium so that they were free either to turn toward or away from the area shaded by the end wall of the aquarium which was toward the

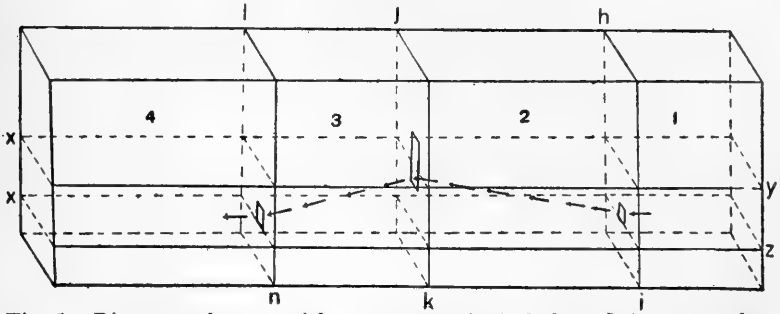

Fig. 1. Diagram of maze with compartments 1, 2, 3, and 4. xz, surface of sand; xy, surface of water; hi, jk, ln, partitions with apertures. Arrows indicate the shortest route through the maze.

sun. The first animal used in this experiment turned toward the shaded area eight times in the first ten trials, and without exception in the next ten trials. This record is typical of the records made by all the animals used in this experiment.

Two glass plates 10 cm. wide were now set up near the middle of the aquarium parallel with each other and about 2 cm. apart at right angles to, and in contact with, one of the lateral walls. An animal placed between these glass plates with its head toward the wall would have to move backward before it would be free to turn toward either end of the aquarium. This arrangement would eliminate any directive influence due to manipulation which might have been present in the previous experiment. One of the animals used in the previous experiment when subjected to a series of trials in this manner turned toward the shaded end of the aquarium without exception in the first ten trials. The glass plates were now placed in contact with the opposite wall of the aquarium in the same manner. The same animal was placed between them with its head toward the wall. Whereas in the previous series of trials it was necessary, in order to approach the shaded area, to turn to the left, it was now necessary to turn to the right. Nevertheless, the animal turned toward the shaded area without exception in ten successive trials.

The above experiment indicates clearly that the larvae of *Ambystoma* are capable of finding a shaded area at the end of the aquarium toward the sun quite as readily as at the opposite end; consequently, the maze was arranged in this manner. For the first series of four larvae two partitions of ordinary painted window screen were placed transversely in the aquarium, approximately 20 and 40 cm., respectively, from the unshaded end. The first partition contained a rectangular aperture 2.5 cm. in width, the lower border of which stood approximately 4 cm. above the sand and 2 cm. below the surface of the water. The second partition contained an aperture of 2.5 cm. square, the lower border of which was at the level of the sand. The larvae were placed in the aquarium without the partitions in place until they became accustomed to seeking the shaded area. The partitions were then put in place. Each of the animals in turn was placed in the compartment at the unshaded end of the aquarium and the time noted until it had passed through the apertures in the partitions and reached the shaded area. Each animal was given three successive trials. These larvae were not again placed in the maze until two days later.. Each animal was again placed in the aquarium without the partitions in place and permitted to seek the shaded area three times. The partitions were then replaced and each animal was given three trials to reach the shaded area by passing through the apertures. These exepriments were repeated on five successive days. On the third day one of the larvae had become sluggish by reason of its approaching metamorphosis and was discarded. After this the series included only three animals. Curve AB, fig. 2, is based on the averages of all the trials of all the animals in the series. The ordinates indicate the time in seconds required for the animal to pass from the compartment at the unshaded end of the aquarium through the apertures in the partitions to the shaded area at the opposite end. The abscissae indicate the days on which the trials were made. This curve drops rapidly from 206.5, which is the average of the first series of trials, to

99 which is the average of the third series, although two days intervened between the first and second series of trials. After this the average time interval remains fairly constant until the sixth series of trials which was made on the seventh day, when the experiment was discontinued by reason of the sluggishness

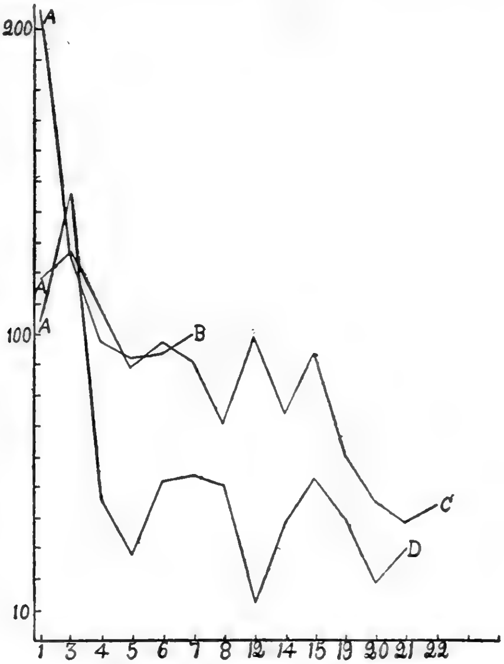

Fig. 2. A B, Curve based on the averages of three trials in successive experiments of all the animals in the first series; A C, Curve based on the averages of the three trials in successive experiments of all the animals in the second series; A D, Curve based on the averages of three trials in successive experiments of larva No. 2 in the second series. The ordinates indicate the time in seconds; the abscissae, the days on which the trials were made.

of the remaining larvae due to their approaching metamorphosis.

The second series consisted of six larvae. For this series three partitions of screen were used in the aquarium as illustrated in fig 1. The first (hi), with an aperture at the bottom 2.5 cm. square, and 8.5 cm. from one end, was placed approximately 10 cm. from the unshaded end. The second (jk), with an aperture at the top 2.5 cm. wide and 6 cm. from the other end, so placed that its lower border was 2 cm. below the surface of the water, was placed approximately 15 cm. from the first. The third partition (ln), with an aperture at the bottom 2.5 cm. square and near the middle, was placed just far enough from the end wall of the aquarium toward the sun to include all of the shaded area.

Without the partitions in place one of the larvae was placed in the aquarium at the unshaded end and permitted to seek the shaded area three times in succession. The partitions were then put in place, the larva placed in compartment 1 at the unshaded end of the aquarium, and the time noted which was required for it to reach the shaded area in compartment 4, after it had passed through the aperture in the first partition. This was repeated twice. All the other larvae in the series were treated in the same way; consequently, each animal was allowed to pass through the maze three times in each experiment. These animals were kept in individual aquaria, and individual records were kept for all of them. Following the initial experiment two days intervened before they could be repeated. They were then repeated on six successive days. Three days again intervened after which the experiments were repeated on the 12th, 14th, 15th, 19th, 20th, 21st, and 22d days. The record includes the time required for each animal to pass through the maze in each of three successive trials on every day on which the experiments were made. However, on the 8th day larva No. 5 became sluggish by reason of its approaching metamorphosis and was discarded. On the 19th day larva No. 1 also became sluggish and was discarded. Consequently, after the 8th day the series includes only five, and after the 19th day, only four animals. Curve AC, fig. 2, represents the averages of the three trials of all the animals in the series on the days on which the experiments were made. It indicates a decided drop from the initial interval of 118.3 sec. to 89.9 sec. on the 5th day. After this there is considerable variation in the time interval required, but it does not again rise higher than 99.1 sec. After the 15th day there is again a decided drop until a low point of 39.1 is reached on the 21st day, although three days intervened after the 15th day until the next series of trials was made.

Curve AD, fig. 2, illustrates the record made by a single individual (No. 2 in the second series). From the average initial interval of 105.7 sec. the curve rises to 146 for the second series of trials, but then drops rapidly to 29.3 for the fourth series, and does not again rise above 54 during the successive series of trials and terminates at 30 for the 13th series of trials on the 21st day following the initial series.

These several curves indicate that the late larvae of *Ambystoma tigrinum* are able, by repetition, to form simple habits. The most rapid progress is indicated early in the experiment. The curves drop rapidly until a more or less constant level is reached. Curve AC indicates a second drop following the 15th day; however, the experiment was not continued long enough to determine whether or not a new low level would have been established.

After the 8th day the animals were not again subjected to experiment until the 12th day. The average interval required to pass through the maze on the 12th day was 28.6 seconds longer than the average for the four days preceding the 8th day. Again the experiment was interrupted from the 15th to the 19th day. The average interval on the 19th day was 33.1 seconds shorter than the average interval on the 15th day, and 22.8 seconds shorter than the average for the 14th and 15th days. Therefore, the record affords no evidence that after the first low level was established the animals were less able to accomplish the task set before them after a period of rest of four days than they were at the beginning of that period. Obviously the simple habits formed were retained during this short interval.

Direct observations indicate that the animals gradually became more and more familiar with the maze during the progress of the experiment, and were able to pass through it with appreciably less effort than in the initial trials. Whereas early in the experiment they usually felt their way along the walls of the aquarium and the partitions and passed through the apertures only when they were found in this manner, later some of the animals not infrequently passed through the apertures without feeling their way along the partitions. The aperture in the middle partition, which was 4 cm. above the level of the sand, was found with greater difficulty than the ones in the first and third partitions which were at the level of the sand, because the animals habitually swam near the bottom. There is no evidence that these larvae recognized the apertures by the sense of sight until they were in close proximity to them. Direct observations indicate rather that the animals which did sometimes pass through the apertures without feeling their way

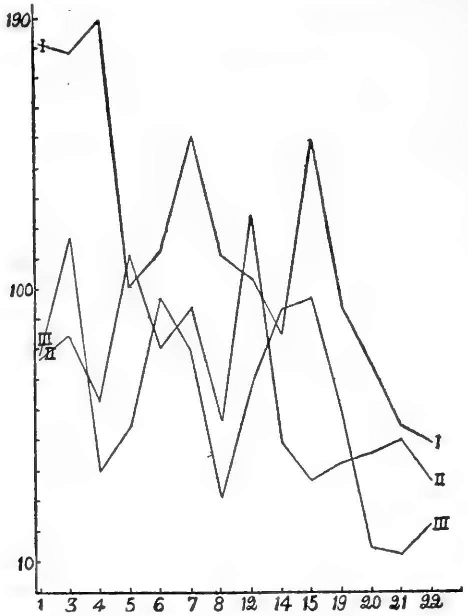

Fig. 3. I, II, and III, curves based on the first, second, and third trials, respectively, of all the animals in the second series. The ordinates indicate the time in seconds; the abscissae, the days on which the trials were made.

along the partitions retained an impression of the general location of the apertures which they had gained by previous experience. The record also indicates that the second and third trials usually resulted in a successful passing through the maze in less time than the first. Curves I, II and III, fig. 3, are based on the average of the first, second and third trials respectively, of all the animals in the second series. While these curves show large variations from day to day, the general level of the second is materially lower than that of the first, and the general level of the third is somewhat lower than that of the second. The average interval for the first trials of all the animals in ten successive series of trials is 136.2 seconds; while that for the second trials is 80.1 seconds; and that for the third trials is 75.9 seconds. Obviously, the advantage of a second trial immediately following a first is much greater than the advantage of a series of trials following a series on the preceding day.

The results of this study justify the conclusion that the late larvae of *Ambystoma tigrinum* are capable, in at least a low degree, of learning by repetition. The running of a simple maze is accomplished in less time and with appreciably less effort in a second and a third trial than in the first trial immediately preceding. The repeated running of the maze at daily or longer intervals results in the acquisition of simple habits which are retained at least for a short time.

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METAMORPHIC CHANGES IN THE DIGESTIVE SYSTEM IN RANA PIPIENS AND AMBYSTOMA TIGRINUM

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INTRODUCTION

The changes involved in the metamorphosis of the frog are in general well known. The resorption of the tadpole's tail, the gradual elongation of the hind limbs, the emergence of the fore limbs, and the initiation of pulmonary respiration are familiar phenomena. Less conspicuous, though quite as important, are the changes which take place in the digestive tube as the young animal, which during its larval life was essentially herbivorous, becomes prepared for a carnivorous diet. These and other internal changes, and the period of fasting which is coincident with them, also involve material reduction in the size and weight of the body.

Metamorphic changes are less extensive in the Urodela than in the Anura. However, the more important changes which occur in the two orders are similar in character. The resorption of the fin-folds and the gills and the initiation of pulmonary respiration in the Urodela are accompanied by important changes in the digestive tube (although the larvae are not herbivorous) and other internal organs which, with the coincident period of fasting, result in a reduction in the size and weight of the body which is only less marked than in the Anura.

Data regarding the function of the leucocytes in the resorption of tissue and the histological changes involved (Barfurth '87, Griffiths '94, Noetzel '95), as well as quantitative observations on the rate and extent of reduction in the size and weight of the body of the tadpole of the frog during metamorphosis (Schaper '02), are available. The more important histological changes involved in the reduction in the length of the digestive

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tube in tadpoles of the frog have been described (Ratner '91). Data regarding the external changes involved in the metamorphosis of *Ambystoma tigrinum* are also available (Chauvin '76, Powers '03). However, a search of the literature reveals no extensive quantitative data on the extent of the changes undergone by the digestive tube and other internal organs either in an Anuran or an Urodelan species.

The present paper sets forth the results of quantitative observations on the reduction in the length of the digestive tube and associated internal changes in correlation with the reduction in the total weight of the body, and the coincident period of fasting during metamorphosis in *Rana pipiens* and *Ambystoma tigrinum.* It also includes a brief consideration of the histological changes in the stomach and intestine which are correlated with the reduction in the length of the digestive tube.

The greater part of this work was carried out at the Iowa Lakeside Laboratory during the summer of 1921. The writer desires to acknowledge his indebtedness to Prof. R. B. Wylie, Director, for the privileges of the Laboratory and for his interest in furthering the work.

QUANTITATIVE DATA REGARDING METAMORPHIC CHANGES

The animals used in this study were collected in the vicinity of the Laboratory during late July and August. Tadpoles representing various stages of development and young frogs were present in abundance. The tadpoles which were still most immature weighed 3.5 to 4.5 grams and represented a stage of development in which the hind limbs were still functionless and had attained a length of not over 5 mm. Those which had attained their maximum larval size weighed 6.5 to 7.5 grams. The larvae of *Ambystoma* also were present in abundance. Those used in this study were relatively small, but quite uniform. Those which were least advanced in their development had attained a length of 9 to 10 cm. and a weight of 5 to 6 grams. Those which had attained their maximum larval size were 11.5 to 12.5 cm. in length and weighed approximately 12 grams. Larvae which were undergoing metamorphosis were present in considerable abundance. Young adults were taken only in small numbers, but many of the larvae completed their metamorphosis in the laboratory.

When collections were brought into the laboratory the animals were separated into groups representing successive stages of development. The larvae and young adults of *Rana* were arranged in nine groups representing as many stages of development, which may be indicated as follows:

Stage 1. Fore limbs concealed, hind limbs not over 5 mm. in length.
Stage 2. Fore limbs concealed, hind limbs 10 to 15 mm. in length.
Stage 3. Fore limbs concealed, hind limbs 30 mm. or over in length.
Stage 4. Fore limbs free, tail not reduced.
Stage 5. Tail reduced to approximately one half maximum size.
Stage 6. Tail almost completely resorbed.
Stage 7. Small frogs just emerged from the water.
Stage 8. Young frogs which had just resumed feeding.
Stage 9. Young frogs actively feeding.

The larvae and young adults of *Ambystoma* were also arranged in nine groups representing as many successive stages of development. The earlier stages in this series can not be characterized as definitely as those in the series of *Rana*. The successive stages may be indicated as follows:

Stage 1. Larvae 9 to 10 cm. in length; weight 5 to 6 grams.
Stage 2. Larvae 10 to 11 cm. in length; weight 7 to 8 grams.
Stage 3. Larvae of maximum size, gills not reduced.
Stage 4. Larvae with resorption of gills and changes in coloration initiated.
Stage 5. Larvae with gills not over half their maximum length, changes in coloration advanced.
Stage 6. Larvae with gills almost completely resorbed.
Stage 7. Metamorphosis apparently complete.
Stage 8. Young adults about to resume feeding.
Stage 9. Young adults actively feeding.

The curves in the accompanying figures are based on the averages of weight determinations and measurements made on specimens selected from the groups representing the successive stages of development. Two series of groups of five spcimens each were used in the case of each species.

Curve A B. fig. 1, illustrates the changes in the total weight of the larvae of *Rana pipiens* as they approach and pass through the period of metamorphosis. It indicates a relatively rapid increase in weight until the maximum larval weight is attained, then an abrupt decrease from an average maximum of 6.8 to an average minimum of 2.9 grams, or a total reduction of 57.3 per cent. This curve corresponds very closely to Schaper's ('02) curve which illustrates the changes in the total weight of *Rana fusca* during the corresponding period. Curve AE, fig. 2, illustrates the changes in the total length of the stomach and intestine during the same period. This curve also shows a rapid rise until the digestive tube has attained its maximum length; then an abrupt decline. It indicates a reduction from an average maximum of 51 to an average minimum of 6 cm., or a total reduction of 88.2 per cent.

Curve AF, fig. 2, illustrates the changes in the length of the stomach alone. This curve drops abruptly until its low point is reached only a little later than the high point in curve AE. It indicates a reduction from an average maximum of 11 mm. to an average minimum of 5 mm., or a total reduction of 54.5 per cent, which occurs somewhat earlier than the reduction in the length of the intestine and is followed immediately by rapid growth both in length and capacity. Curve AC, fig. 1, illustrates the changes in the total weight of the stomach and intestine with contents. This curve is based on the average weight determinations multiplied by 5. It shows a rapid rise until the digestive tube has attained its maximum length; then an abrupt decline. It indicates a reduction in weight from an average maximum of 1.4 to an average minimum of .1 gram, or a total reduction of 92.8 per cent. Curve AD, fig. 1, illustrates the corresponding changes in the weight of the liver. It also is based on the average weight determinations multiplied by 5. This curve indicates a reduction in the weight of the liver from an average maximum of 0.3 to an average minimum of .06 gram, or a total reduction of 80 per cent. The pancreas also undergoes material reduction in weight which is initiated somewhat earlier than the reduction in the length of the digestive tube and the weight of the liver. It also undergoes changes in form and in its position with respect to the liver and the duodenum. By reason of the small size of the pancreas no attempt was made to illustrate its changes by means of curves.

The curves representing respectively the length of the stomach and intestine and the total weight of these organs with contents in the larvae of *Rana pipiens* reach their highest point at approximately the same time. The curve representing the total weight of the animals reaches its highest point a little later. Obviously, the larvae cease to feed before resorption of the tail is initiated. The period of fasting continues until the metamorphic changes are complete and the little frogs have emerged from the water. When the larvae cease feeding the stomach and intestine are well filled. The ingested material, therefore, accounts for the greater part of the total weight of these organs with their contents when the curve reaches the highest point. As the metamorphic changes advance the contents of the digestive tube are gradually eliminated until the residue left in the large intestine becomes almost negligible. Therefore, the lowest point in the curve represents approximately the weight of the stomach and the intestine without contents. Many of the little frogs which were collected in the grass after they had emerged from the water were still without food in their stomachs. Obviously, feeding is not resumed until at least a short time after the little frogs emerge. Larvae which had attained their maximum size when they were brought into the laboratory, and in which resorption of the tail was initiated soon after, were completely metamorphosed nine to ten days later. Therefore, it may be assumed that the period of fasting is of at least ten days' duration. This is probably a fairly accurate estimate of the interval required for the completion of the metamorphic changes in this species. It corresponds closely with the interval required by the metamorphic changes in *R. fusca* as determined by Schaper's observations on larvae which were reared in the laboratory.

The liver does not reach its maximum weight until the resorption of the tail and the digestive tube are well advanced. It then decreases rapidly until it reaches the minimum weight about the time metamorphosis is completed.

Curve A′B′, fig. 1, illustrates the changes in the total weight of the larvae of *Ambystoma tigrinum* as they approach and pass through the period of their metamorphosis. This curve shows a rapid rise until its highest point is reached; then an abrupt decline. It indicates a reduction in weight from an average maximum of 12.2 to an average minimum of 8.7 grams, or a total reduction of 28.7 per cent. Curve A′E′, fig. 2, illustrates the changes in the total length of the stomach and intestine during the same period. It also shows a rapid rise until its highest point is reached; then an abrupt decline. It indicates a reduction in length from an average maximum of 22.3 to an average minimum of 12.1 cm, or a total reduction of 45.8 per cent. Curve A′F′, fig. 2, illustrates the changes in the length of the stomach alone. Like the preceding curve, it shows a rapid rise until its highest point is reached; then an abrupt decline. It indicates a reduction in length from an average maximum of 31 mm. to an average minimum of 14 mm., or a total reduction of 54.8 per cent. Curve A′C′, fig. 1, illustrates the corresponding changes in the weight of the stomach and intestine with contents. It is based on the averages of the weight determinations multiplied by 5. It indicates a reduction from an average maximum of 1.02 to an average minimum of .32 grams, or a total reduction of 68.6 per cent. Curve A′D′, fig. 1, illustrates the changes in the weight of the liver during the period of metamorphosis. It also is based on the averages of the weight determinations multiplied by 5. This curve indicates a gradual increase in the weight of the liver throughout the period of metamorphosis. The pancreas in the larvae of *Ambystoma* is relatively small and, like the liver, probably undergoes no reduction in weight during metamorphosis.

The curves representing the total body weight and the weight of the stomach and intestine in the larvae of *Ambystoma tigrinum*, with contents, reach their highest point at the same time. The curve representing the length of the stomach and intestine reaches its highest point a little later. Obviously, the larvae of this species cease feeding before the digestive tube has attained its maximum length. At this time the stomach and intestine are well filled. As the metamorphic changes advance, the contents of the digestive tube are gradually eliminated until the residue of the undigested matter becomes almost negligible. The major portion of the weight indicated by the high point in this curve is made up by the ingested matter. The weight indicated by the low point is approximately the weight of the stomach and intestine without contents.

The period of fasting continues until metamorphosis is complete. Larvae in which metamorphic changes were obviously initiated, but whose fins and gills were still of approximately maximum size when they were brought into the laboratory, emerged as young adults and resumed feeding nine days later. This is probably a fair estimate of the interval required for the completion of a metamorphosis in the animals under observation. *Ambystoma tigrinum* is an exceedingly variable species. While the Ambystoma population of any given kettle-hole was relatively uniform, specimens taken from various kettle-holes in the vicinity showed wide variations in size. While it is quite probable that metamorphosis requires no longer interval in the larger than in the small varieties, the data at hand do not justify the conclusion that the interval of approximately nine days here indicated is the average interval for the species. Powers' ('03) observations indicate an interval considerably shorter than nine days.

The morphological changes involved are far less extensive in *Ambystoma* than in *Rana*. The difference in the extent of reduction in the length of the digestive tube and the changes in the size of the liver in these two types of Amphibia, doubtless are correlated with their habits of feeding. The larvae of *Rana* are primarily herbivorous while those of *Ambystoma* are essentially carnivorous. The relatively enormous length of the digestive tube in the larvae of *Rana* is an adaptation correlated with their herbivorous diet. The great reduction in the length of the digestive tube during metamorphosis is an essential part of the adjustment of the little frog to a carnivorous diet. The lesser reduction in the length of the digestive tube during metamorphosis in *Ambystoma*, doubtless must be explained on the same basis. While the larvae of *Ambystoma* are essentially carnivorous they are not strictly limited in their diet. Those used in this study were taken in a habitat in which there was very little vegetation. Their food consisted primarily of aquatic insects and insect larvae. However, the contents of the digestive tube included some mud. Larvae of *Ambystoma* taken in another habitat in which algae were growing in abundance were found to be feeding on these plants extensively. Their stomach contents consisted almost exclusively of Entomostraca and minute algae. Doubtless, the diet of the adults of *Ambystoma tigrinum* is much more strictly carnivorous. Therefore, the reduction in the length of the digestive tube during metamorphosis is probably an essential part of the adjustment of the animals to the more restricted carnivorous diet. The relatively smaller size of the liver in *Ambystoma* than in *Rana* during larval life is probably correlated with the lower carbohydrate content in the diet. Inasmuch as the liver does not assume larger proportions in the larvae of this species, an actual reduction in the size of this organ need not take place during metamorphosis.

HISTOLOGICAL CHANGES IN THE STOMACH AND INTESTINE DURING METAMORPHOSIS

The histological structure of the digestive tube of certain types of Amphibia, especially the frog, is adequately described. The histological changes in the stomach and intestine of *Rana temporaria* which are correlated with the reduction in the length of the digestive tube during metamorphosis, were set forth by Ratner ('91). The purpose of the present histological study is to extend our knowledge of the structural changes in the stomach and intestine which are correlated with the reduction in the length of the digestive tube during metamorphosis in *Rana*, and to compare with these changes the corresponding structural changes in the stomach and intestine of an Urodelan species in which the reduction in the length of the digestive tube during metamorphosis is less extensive than in the Anura.

The accompanying microphotographs illustrating the histological structure of the stomach and intestine were all taken under the same magnification, viz., 165 diameters. If the digestive tube had been equally distended in every case the thickness of the corresponding layers in the successive stages could be compared directly. Inasmuch as the digestive tube was still well filled with ingested material during the two earlier stages of *Rana pipiens* illustrated (figs. 3, 4, 8, 9), it may be assumed that in these cases the corresponding portions of the digestive tubes were distended to approximately the same degree. On the other hand, the digestive tube was practically empty during the two later stages of *Rana* illustrated (figs. 5, 6, 10, 11). Consequently, the corresponding portions were contracted to approximately the same degree. Therefore, in comparing the thickness of the several layers of the wall of the digestive tube in the earlier and later stages, allowance must be made for the difference in the state of contraction. The sections of the intestine of the larvae of *Ambystoma tigrinum* illustrated (figs. 12, 13) were taken from portions of the intestine which were contracted in approximately the same degree. Consequently, the corresponding layers in the two stages illustrated may be compared directly.

The reduction in the length and capacity of the stomach during metamorphosis in *Rana* is less extensive than that of the intestine. Nevertheless, the structural changes in the stomach are well marked. In tadpoles which are still growing and whose digestive tube has not yet reached its maximum length, the walls of the stomach and intestine remain relatively thin and delicate. As pointed out in an earlier section of this paper the reduction in length occurs somewhat earlier in the stomach than in the intestine. The gastric glands arise earliest at the pyloric end and gradually advance toward the cardiac end of the stomach. Glands are not present in the most anterior portion of the stomach until shortly before this organ has attained its maximum larval length, which occurs in tadpoles with hind limbs 5 to 15 mm. in length. Figure 3 is a microphotographic reproduction of a portion of a transverse section of the stomach of a tadpole in which the process of reduction in the length of the stomach was already initiated. The serosa and muscularis are very thin. Longitudinal muscle fibers are not apparent. The muscularis is, therefore, represented by relatively few circular fibers. The deep portions of the gastric glands which are still loosely aggregated come into very close proximity with the muscularis. The submucosa is represented by a small amount of loose connective tissue which lies between the glands. As the process of reduction advances the serosa and muscularis of the stomach become appreciably thicker. A subserous layer of connective tissue makes its appearance, but longitudinal muscle fibers are still absent. The existence of longitudinal muscle in the stomach of the frog has been denied by certain observers (Valatour; P. Schultze). On the other hand, Ratner states that few longitudinal muscle fibers are present even during the earlier metamorphic changes. The present study warrants the conclusion that longitudinal muscle fibers are present in the muscularis of the stomach during metamorphosis. The submucous connective tissue also becomes more abundant and the gastric glands become arranged more compactly. An advanced stage in the progress of these changes is illustrated microphotographically in figure 4, which is taken from a transverse section of the stomach of a tadpole in which this organ had almost reached its maximum size during metamorphosis. Figure 5 illustrates microphotographically a portion of a transverse section of the stomach of a tadpole in which the growth of this organ after reduction was initiated. All the layers except the mucosa are relatively thicker than in the preceding stage. The muscularis is now represented by a thick layer of compactly arranged fibers. The submucosa consists of a well defined layer of connective tissue between the muscularis and the deep portions of the gastric glands. The latter are short and more compactly arranged than in the preceding stages. Figure 6 illustrates microphotographically a portion of a transverse section of the stomach of a young frog recently emerged from the water. The muscularis is not proportionately thicker than in the preceding stage. The submucosa is somewhat thicker and more fibrous. The gastric glands are quite fully developed. In short, the stomach now shows the histological structure of the stomach of the adult frog.

The small intestine of the frog tadpole is arranged in a characteristic double spiral coil which, while the tadpole is growing and actively feeding, causes marked distension of the abdomen. As the tadpole undergoes metamorphosis and the intestine becomes shorter, the spiral coil becomes smaller and finally gives way to the arrangement of the small intestine in the adult frog. Several stages in the reduction of the intestinal coil are illustrated photographically in figure 7. Until the process of shortening sets in, the wall of the intestine is extremely thin and fragile. It consists of little more than the thin serous and muscular layers and the mucous epithelium which, while the intestine is moderately filled with ingested material, is closely applied to the muscularis with but little connective tissue intervening. This condition is illustrated microphotographically in figure 8 which is taken from a transverse section of the small intestine of a tadpole in which approximately 50 per cent of the reduction in the length of the digestive tube had taken place. The intestinal wall is now appreciably thicker than in the preceding stage. The added thickness is made up largely of the increase in the thickness of the muscularis and the submucosa. As the shortening of the digestive tube progresses the intestinal wall becomes thicker, and all the tissues become more compact. Figure 10 illustrates a portion of a transverse section of the small intestine of a tadpole in which the digestive tube had reached its minimum length during metamorphosis. The small intestine is now practically without food content and its caliber is greatly reduced by reason of the contraction of the circular muscles. Consequently, the mucosa and submucosa are thrown into large longitudinal folds. The thickness of the several layers, as indicated by this and the preceding figure, may not be compared directly by reason of the difference in the caliber of the intestine. Nevertheless, figure 10 indicates a relatively enormous increase in the thickness of all the layers except the mucosa. As the metamorphic changes advance to completion and the little frog resumes feeding the muscularis and the submucosa become relatively somewhat thinner and the mucosa is thrown into numerous folds. As illustrated in figure 11, which is taken from a transverse section of the small intestine of a young frog about the time feeding is normally resumed, the histological structure is now essentially that of the small intestine of the adult frog.

The most marked changes in the histological structure of the stomach and intestine in *Rana* during metamorphosis, as noted above, consist in the increased thickness of the several layers, especially the muscularis and submucosa, the more compact arrangement of the gastric glands and the folding of the intestinal epithelium. These changes are coincident with the reduction in the length and caliber of the digestive tube and are accomplished in a relatively short time. Obviously, the increase in the thickness of the several layers in the walls of the stomach and intestine is not accomplished by prolification of the tissue elements, but by rearrangement of those already present. As pointed out by Ratner, mitotic figures occur only rarely in these tissues during the period of metamorphosis. Furthermore, the increase in the volume of the tissue per unit length of the tube occurs so rapidly that it could not be accounted for by the prolification of cellular elements alone. Neither is there any evidence of degeneration or destruction of tissue in the walls of the digestive tube while the process of shortening is going on, as would necessarily be the case if the tissue elements did not become rearranged and aggregated. By what mechanical process the shortening of the tube and the rearrangement of the tissue elements is accomplished is not clear. As suggested by Ratner, the aggregation of the muscle tissue is the important factor. The subserosa and submucosa necessarily become thicker and more compact in response to the changes in the muscularis. Likewise the epithelium becomes more compact and, with the submucosa, is thrown into numerous folds as the tube is reduced in length and caliber.

The subserous and submucous connective tissue shows more evidence of normal growth changes during the metamorphosis than any of the other tissues in the walls of the stomach and intestine. At the beginning of metamorphosis the connective tissue in these layers is not only very meager but also contains very few fibers. As metamorphosis advances, this connective tissue becomes more fibrous and the number of cellular elements is materially increased. After the metamorphic changes are completed and the digestive tube resumes growth this connective tissue soon assumes the character of the connective tissue in the digestive tube of the adult frog. The difference in the submucosa of the stomach during the later stages of metamorphosis and in the recently emerged frog is well illustrated in figures 5 and 6.

The histological changes in the stomach and intestine of *R. pipiens* during metamorphosis, as described in this paper, conform in general to the corresponding changes in *R. temporaria* as described by Ratner.

As indicated in an earlier section of this paper the reduction in the length of the digestive tube during metamorphosis is much less extensive in the Urodela than in the Anura. Consequently, the changes in the histological structure of the stomach and the intestine which are correlated and coincident with the reduction in the length of the digestive tube, though similar in character, are less extensive in *Ambystoma tigrinum* than in *Rana pipiens.* The walls of the stomach and intestine in the larvae of the former are never as thin and fragile as in those of the latter species at the corresponding stage of development. As the larvae of *Ambystoma* undergo metamorphosis and the digestive tube becomes shorter, the walls of the stomach and intestine also increase somewhat in thickness. However, the changes in the layers are much less marked than the corresponding changes in the larvae of *Rana*. Figure 12 illustrates microphotographically a portion of a transverse section of the small intestine of a larva of *Ambystoma* in which the reduction in the length of the digestive tube was well advanced. Figure 13 illustrates a portion of a transverse section of the small intestine of a young adult *Ambystoma* which had not yet resumed feeding. The intestine was contracted to approximately the same degree in both cases and the sections were taken at corresponding levels. The difference in the thickness of the corresponding layers in these two stages is unimportant. Obviously, the tissues are much more compact in the latter than in the former. The submucosa is still very loose and contains relatively few fibers in the former, whereas in the latter it is more compact and more fibrous. Furthermore, during the later stages of metamorphosis the mucosa is thrown into a few large folds, while after metamorphosis the folds of the mucosa are smaller, more definite and more numerous. The structure illustrated in figure 13 is essentially the structure of the intestine of the adult. Inasmuch as the histological changes in the stomach and intestine of *A. tigrinum* during metamorphosis, though less extensive, are similar in character to the corresponding changes in *R. pipiens* a more detailed description of them at this time would be superfluous. There is no more evidence that the increase in the thickness of the several layers in the walls of the stomach and intestine during metamorphosis involves active cell proliferation in *Ambystoma* than in *Rana*. On the other hand, all the facts observed indicate that the increase in thickness is accomplished by rearrangement and aggregation of the elements already present.

SUMMARY

The period of metamorphosis and the coincident period of fasting occupy approximately ten days in *Rana pipiens* and nine days or less in *Ambystoma tigrinum.*

Quantitative data presented indicate the following changes during metamorphosis:

	R. pipiens	A. tigrinum
Average reduction in total weight	57.3 per cent	28.7per cent
Average reduction in length of stomach and intestine	82.2 per cent	45.8 per cent
Average reduction in length of stomach	54.5 per cent	54.8 per cent
Average reduction in weight of stomach and intestine with contents	92.8 per cent	68.6 per cent
Average reduction in weight of liver	80 per cent	none

The more important histological changes in the stomach and intestine during metamorphosis consist in increasing thickness of the several layers and more compact aggregation of the tissue elements as the reduction in the length of the digestive tube takes place. The increase in the thickness of the several layers does not involve active cell proliferation, but is accomplished by rearrangement and aggregation of the elements already present.

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PLATE I

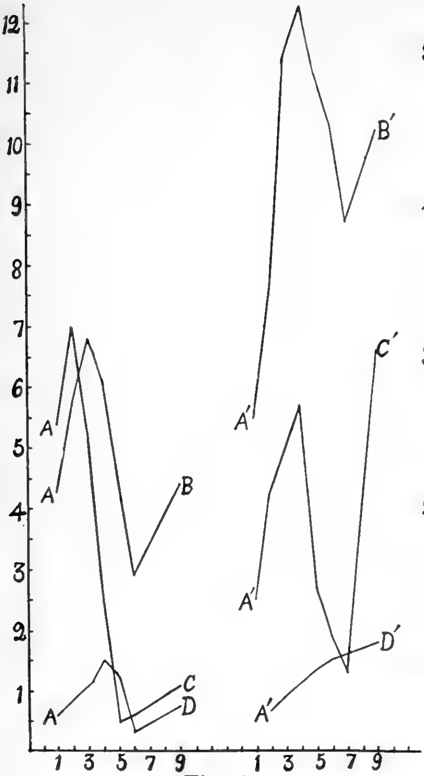

Fig. 1

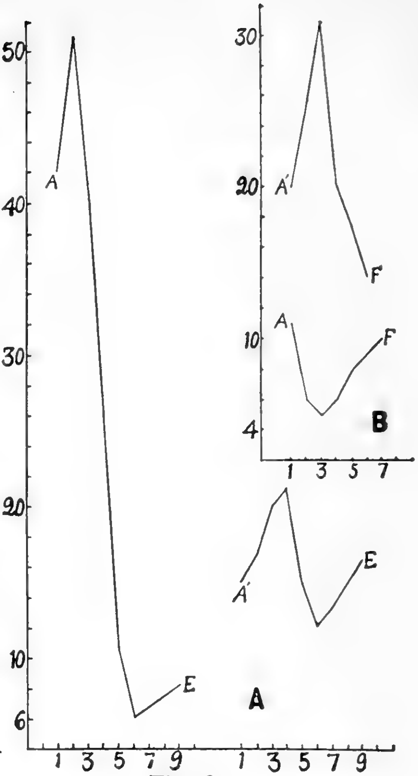

Fig. 2

Fig. 1. Curves illustrating changes in weight during metamorphosis. The ordinates indicate weight in grams; the abscissae, stages in development as defined in the text. AB, Curve of total weight of *Rana pipiens;* A'B', Curve of total weight of *Ambystoma tigrinum;* AC, Curve of weight of stomach and intestine with contents in *R. pipiens;* A'C', Curve of weight of stomach and intestine with contents in *A. tigrinum; AD,* Curve of weight of liver in *R, pipiens;* A'D', Curve of weight of liver in *A. tigrinum*

Fig. 2. Curves illustrating changes in length of stomach and intestine during metamorphosis. The ordinates indicate length in cm. in A. and in mm. in B; the abscissae, stages in development as defined in the text. AE, Curve of length of stomach and intestine in *R. pipiens;* A'E', Curve of length of stomach and intestine in *A. tigrinum;* AF, Curve of length of stomach in *R. pipiens;* A'F', Curve of length of stomach in *A. tigrinum*

PLATE II

Fig. 3. Microphotograph (x165) from a transverse section of the stomach of a tadpole in which the reduction in the length of this organ was initiated

Fig. 4. Microphotograph (x165) from a transverse section of the stomach of a tadpole in which the reduction in the length of this organ was well advanced

Fig. 5. Microphotograph (x165) from a transverse section of the stomach of a tadpole in which the growth of this organ after reduction was initiated

Fig. 6. Microphotograph (x165) from a transverse section of the stomach of a young frog about the time feeding is resumed

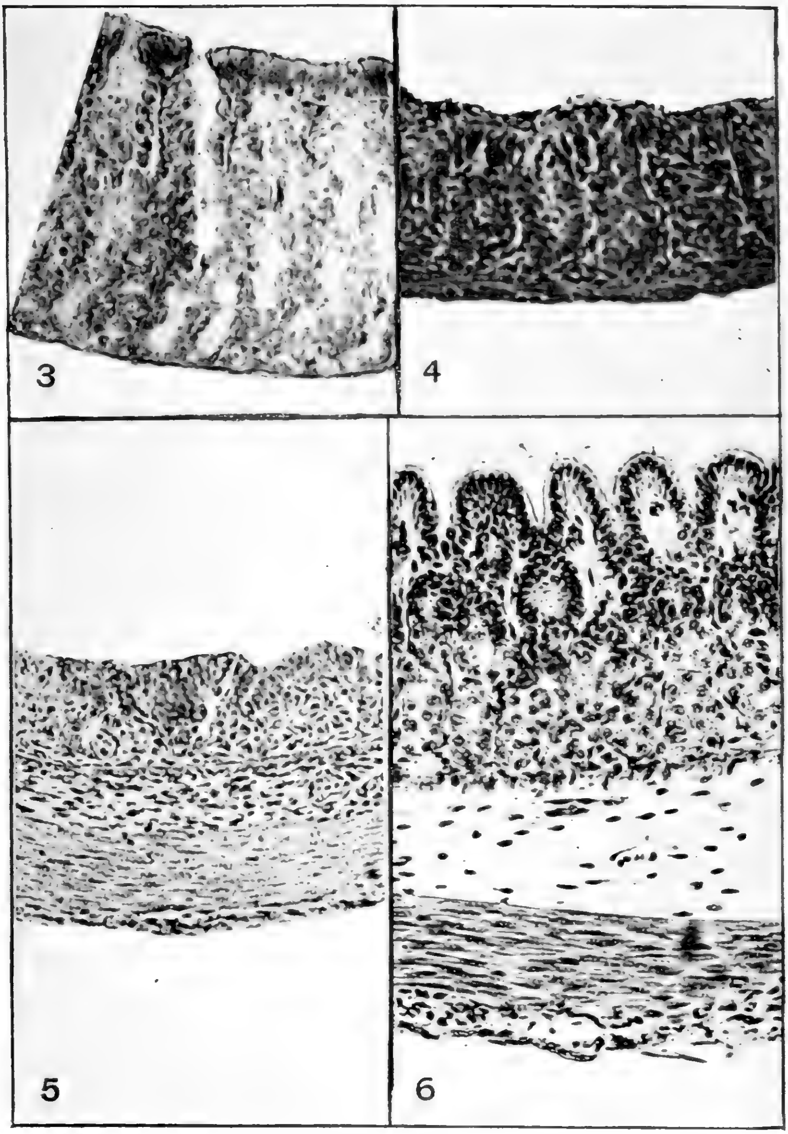
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PLATE III

Fig. 7. Photograph illustrating successive stages in the reduction of the intestinal spiral coil in tadpoles during metamorphosis

Fig. 8. Microphotograph (x165) from a transverse section of the small intestine of a tadpole in which the digestive tube had nearly reached its maximum length

Fig. 9. Microphotograph (x165) from a transverse section of the small intestine of a tadpole in which approximately 50 per cent of the reduction in the length of the digestive tube had taken place

Fig. 10. Microphotograph (x165) from a transverse section of the small intestine of a tadpole in which the digestive tube had practically reached its minimum length during metamorphosis

Fig. 11. Microphotograph (x165) from a transverse section of the small intestine of a young frog about the time feeding is resumed

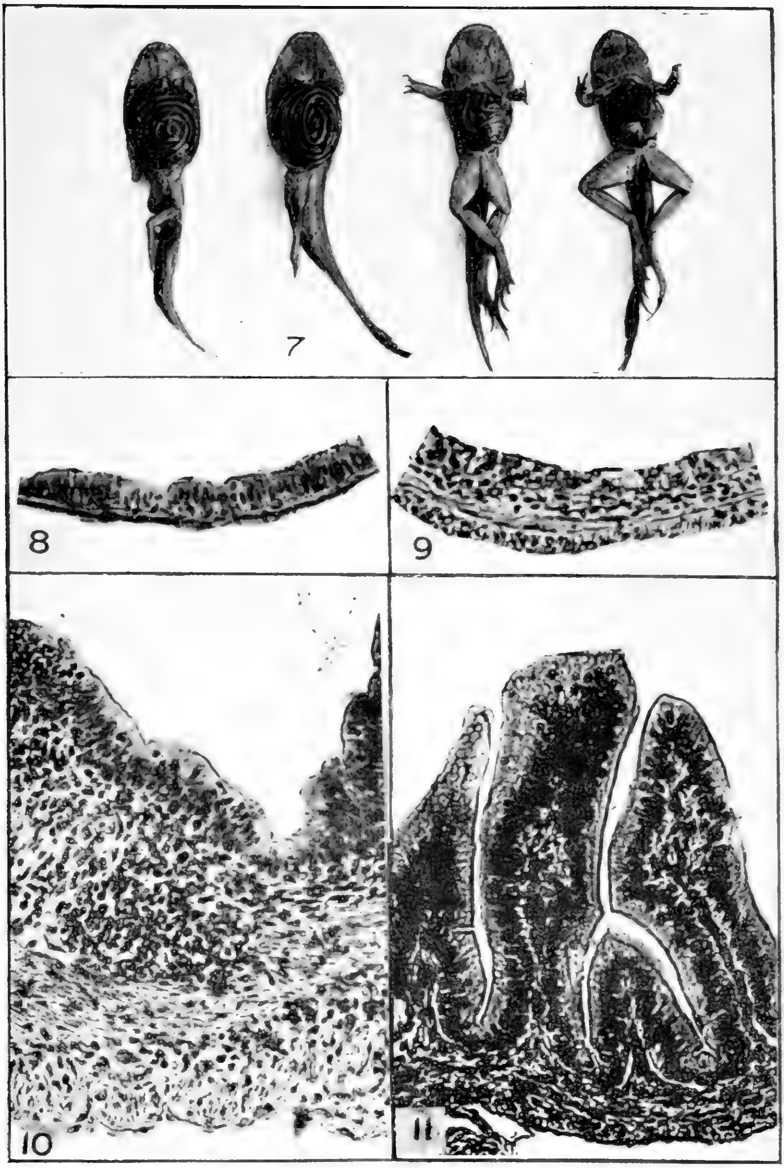
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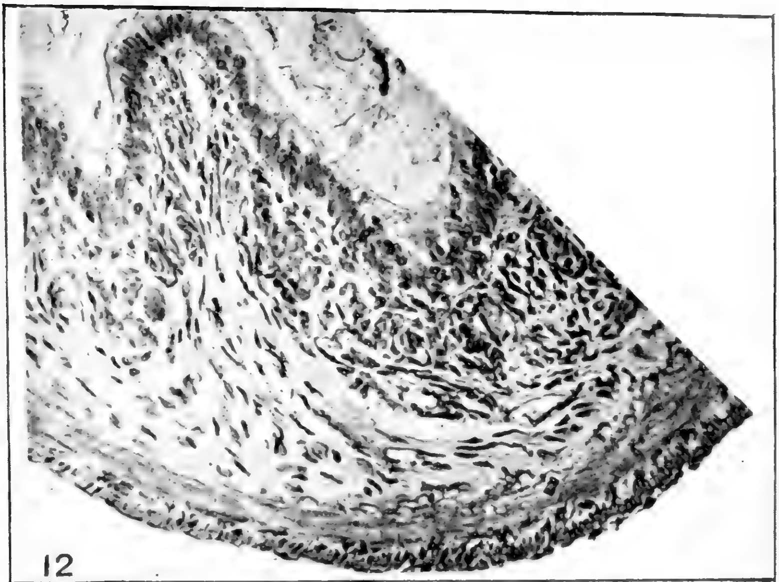
PLATE IV

Fig. 12. Microphotograph (x165) from a transverse section of the small intestine of a larva of *Ambystoma* in which the reduction in the length of the digestive tube was well advanced

Fig. 13. Microphotograph (x165) from a transverse section of the small intestine of a young adult *Ambystoma* before feeding was resumed



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THE FEEDING REACTIONS OF AMBYSTOMA TIGRINUM (GREEN)

By Albert Kuntz and José Zozaya
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The following experimental study is based on a large number of late larvae and young adults of *Ambystoma tigrinum.* The majority of the animals used were taken in an upland kettle-hole in which they were present in great abundance. They were relatively small, measuring 8 to 10 cm. in length and weighing 10 to 12 grams. The majority of the animals taken in this habitat were late larvae. The rest were young adults many of which had scarcely completed their metamorphosis. The other animals used were taken in a larger kettle-hole lying somewhat lower. The species was less abundant in this habitat, and the individuals were much larger, measuring 18 to 20 cm. in length and weighing approximately 40 grams. The majority of these animals also were late larvae, the rest were young adults which had scarcely completed their metamorphosis. All the animals used were collected during the latter half of July and August. Many of the animals taken as larvae completed their metamorphosis while under observation in the laboratory.

This study was carried out at the Iowa Lakeside Laboratory during the season of 1920. The writers desire to acknowledge their indebtedness to Prof. R. B. Wylie, Director, for the opportunity of working at the Laboratory and for his interest in furthering the work.

Larvae. All the larvae which had not yet entered the final phase of their metamorphosis when they were taken were well fed and manifested little or no interest in food which was presented to them. Some would accept and eat somewhat reluctantly bits of meat which were held before them, others would pay no attention to food. After being kept in an aquarium without food for several days they manifested hunger by seizing and eating bits of meat which were held before them, or

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by following bits of meat or other small objects which were moved about in the aquarium.

A study of the behavior of the hungry animals in the presence of food or other objects which stimulate their interest, reveals at least two distinct reactions. They first approach, then seize or attempt to seize an object. If the object is within easy reach an attempt may be made to seize it without any apparent preceding movement. In his study of the feeding reactions of the spotted newt (*Diemyctylus viridescens*) Copeland ('13)[1] described an "approaching," a "nosing," and a "seizing" reaction. Following Copeland, we will designate the movement toward the object the "approaching reaction" and the attempt to seize it the "seizing reaction." We were unable to recognize any reaction of the larvae of *Ambystoma tigrinum* which corresponds to the "nosing reaction" of *Diemyctylus viridescens* described by Copeland.

When a bit of meat held with forceps or probe, or suspended by a thread, is moved about in the water in the presence of the hungry animals it soon attracts their attention. As soon as one of the animals discovers and pursues it, others near by are attracted and pursue it also. If any of them approach it sufficiently closely they seize or attempt to seize it. If a small inedible object is presented in the same way, the hungry animals react essentially in the same manner. Obviously, the stimuli which play the major part in these responses are received through the sense of sight.

When a bit of meat is held quietly in the water, care being taken that the animals do not observe the movements involved in bringing it into position, the hungry larvae respond less promptly. However, in a relatively short time one or more of the animals are attracted, approach, and seize or attempt to seize it. It is not apparent in many instances whether the meat is detected by the olfactory sense or by the sense of sight. The normal movements of the animals in the aquarium may bring the meat into the field of vision of some of them before they are attracted by its odor. As soon as one or more of the animals approach the meat others are attracted by their move-

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[1]Copeland, M. The olfactory reactions of the spotted newt, *Diemyctylus viridescens* (Rafinesque)—Jour. An. Behavior *3*: 260-273. 1913.

ments. On the other hand, it is quite apparent in many instances that the animals respond before the meat is detected by sight. A small inedible object held quietly in the water may be approached as promptly as a bit of meat if in the normal movements of the animals it falls within their range of vision. They approach and may even seize it, but do not manifest as great interest in it as in an edible object. Obviously the discrimination between edible and inedible objects involves the olfactory sense.

These general observations suggest that the sense of sight plays a very important part in the approaching reaction, and that not uncommonly this reaction is followed more or less spontaneously by the seizing reaction. The determination of the relative importance of the sense of sight and the olfactory sense in the feeding reactions requires more exact experimental data. The results of experiments designed to throw some light on this problem are recorded below.

Twenty-two hungry larvae were placed in an aquarium (18 x 28 inches) containing water three inches in depth over a bed of sand. A bit of meat was held quietly near the center of the aquarium and approximately one inch below the surface of the water until it was seized. Each animal which seized a bit of meat was removed from the aquarium before the next trial was made in order that the same animal might not seize more than one bit of meat. Twenty trials resulted in an average interval of 60.5 seconds during which a bit of meat was held in position before it was seized. Several hours later, with all of the animals in the aquarium, bits of meat were offered in the same manner, but none of the animals were removed during the entire series of trials. Under these conditions twenty-four trials resulted in an average interval of 27.1 seconds during which a bit of meat was held in position before it was seized. In this experiment some of the animals responded much more quickly than others, and seized more than one bit of meat. Indeed some of them responded more promptly and more vigorously after having seized a bit of meat than when they were attracted by the meat for the first time. A bit of meat suspended by a thread was now moved slowly to and fro along the midline of the aquarium approximately one inch below the surface of the water. Twenty-five trials resulted in an average interval of 15.2 seconds from the time the meat was lowered into the water until it was seized.

Obviously, in the above experiments the food was detected by the sense of sight. Doubtless the detection of food in the water by the olfactory sense would require longer time intervals. The results indicate that the animals respond more promptly after savory food has been tasted than in the initial trials. They also indicate that these animals become interested in and approach moving objects much more promptly than objects which are not in motion.

In another experiment with the same animals in the aquarium, a bit of meat was dropped on the sand at the bottom. Fifteen trials resulted in an average interval of 3 minutes and 18 seconds during which the meat lay on the sand before it was seized and eaten. In some instances the normal movements of the animals about the aquarium brought some of them so close to the meat that it could be detected by sight. More frequently, however, the behavior of the animals indicated that they were stimulated by the presence of the meat before it was seen by any of them. When the results of this experiment are compared with the results of the experiments cited above, it becomes apparent that these animals find objects suspended or moving in the water much more readily than objects lying on the bottom. This fact, as well as the observed behavior of the animals, suggests that the olfactory sense plays a much more important part in the finding of food when it is in contact with the bottom than when it is suspended or moving in the water.

As determined by examination of their stomach contents, the normal food supply of the larvae of *Ambystoma tigrinum* in the habitat in which the animals under observation were taken, consisted largely of Entomostraca and minute algae. These organisms are everywhere present in the water and are not secured by active pursuit. On the other hand, the larvae of *Ambystoma* feed also on aquatic insects and insect larvae. The latter are found primarily on the bottom. In view of these facts the longer interval required to find food on the bottom of the aquarium than food suspended or moving in the water, can not be accounted for by the normal feeding habits of the animals, but suggests that the finding of food on the bottom depends primarily on the olfactory sense.

An attempt was now made to compare the reactions of these animals to food and odorless inedible objects when the difference between them could not be detected by the sense of sight. Two packets of gauze, one of which contained raw meat, the other cotton, were suspended in the water a few inches apart. During the first interval of ten minutes the packet containing the meat was approached and seized or nibbled 17 times; the packet containing the cotton was approached 11 times, but was not seized or nibbled. During a second ten minute interval the packet containing the meat was seized or nibbled 21 times, but the packet containing the cotton was approached a few times, but was not seized or nibbled. Two packets, each of which contained only cotton, were now suspended in the water for ten minutes. The animals paid little attention to them. They were approached a few times but neither of them was seized or nibbled. The responses elicited by the packets containing raw meat and cotton, respectively, indicate quite clearly that while, under the conditions of the experiment, sight played the more important part in the approaching reaction, the seizing reaction was determined primarily by the olfactory sense except when it followed the approaching reaction more or less spontaneously.

In order to eliminate the sense of sight five animals, all of which manifested hunger, were subjected to an operation in which the eyes were destroyed. One hour later they all seized and ate crayfish's meat which was held before them. They were then placed in a circular aquarium 10 inches in diameter containing water 3 inches in depth. Crayfish's meat was dropped on the bottom at the center of the aquarium and the time which elapsed until it was seized was recorded. Ten trials resulted in an average interval of 84 seconds. On the following day crayfish's meat was again dropped on the bottom of the aquarium in the same manner. In this instance five trials resulted in an average interval of 26.4 seconds during which the meat lay on the bottom of the aquarium before being seized.

Five normal animals were now placed in the circular aquarium and offered crayfish's meat in the same manner. Five trials resulted in an average interval of 6 minutes and 31 seconds during which the meat lay on the bottom of the aquarium before it was seized and eaten.

On the following day the five blinded animals were again placed in the circular aquarium in water 3 inches in depth. Crayfish's meat was held by means of a pair of forceps just beneath the surface of the water near the center of the aquarium. The animals showed by their general behavior that they recognized the presence of food and apparently searched for it. However, none of them succeeded in finding it during an interval of ten minutes. At the close of this interval a bit of crayfish's meat dropped on the bottom at the center of the aquarium was seized in 25 seconds.

The results of the above experiment show clearly that while the normal animals discover food suspended in the water more readily than food lying on the bottom, the blinded animals discover food lying on the bottom more readily than food suspended in the water. As pointed out above, the normal animals detect food suspended or moving in the water largely by the sense of sight. The blinded animals rarely moved away from the walls or floor of the aquarium while searching for food. They apparently depended on contact for guidance in their movements. They could readily find food on the floor of the aquarium, being attracted by its odor; however, they could not find food suspended in the water because they groped along the walls of the aquarium. The more strongly they were stimulated by the odor of the food the more vigorous became their movements; consequently, the more closely they clung to the walls of the aquarium.

In order to test the olfactory sense still further these blinded animals were offered pledgets of cotton some of which were soaked in water, others in a watery extract of crayfish's meat. They manifested no interest in the pledgets of cotton soaked in water; however, when the pledgets of cotton soaked in the extract of crayfish's meat were presented they were promptly seized and in some instances swallowed. In some instances an attempt to swallow the cotton failed, and it was rejected after several movements of the jaws. After having seized several bits of cotton soaked in the extract of crayfish's meat two of the animals somewhat reluctantly seized pledgets of plain cotton which were brought in contact with their mouths, but made no attempt to swallow them. The results of these experiments show clearly that in the absence of sight these animals were guided in their feeding reactions by the olfactory sense.

An attempt was now made to eliminate the sense of smell by filling the nares loosely with cotton. A more drastic operation on these small animals, e. g., severing the olfactory nerves, did not seem advisable. The nares of five animals were filled loosely with cotton. One hour later they all appeared quite normal and were leisurely moving about the aquarium. Crayfish's meat dropped on the floor of the aquarium apparently was not noticed by them, neither would they seize bits of crayfish's meat held before them. On the following day they again refused to accept bits of crayfish's meat held before them. The cotton was now extracted from the nares of three of the animals. The nasal epithelium was inflamed and somewhat œdematous. Crayfish's meat held before them was again refused. On the following day one of the animals from the nares of which the cotton had been extracted seized and ate a bit of the crayfish's meat, but the others still manifested no interest in food held before them. These animals manifested less interest in food during the entire series of experiments than normal hungry animals would in inedible objects presented to them in the same manner. We are of the opinion that the sense of smell was effectively eliminated by filling the nares loosely with cotton, but that the animals were somewhat discomfited by the inflammation of the nasal epithelium which followed and that the olfactory sense was not restored following the extraction of the cotton until the inflammation subsided. Obviously their failure to accept food held before them was in part determined by their discomfort. More crucial experiments designed to eliminate the sense of smell in young adults will be discussed presently.

Young adults. As pointed out above, the larvae of *Ambystoma tigrinum* cease feeding as they approach the final phase of their metamorphosis, and do not resume feeding until their metamorphosis is completed; consequently the majority of the young adults taken as well as those which emerged from the larval stage in the laboratory manifested no interest in food for some time. Even after they manifested hunger by seizing and eating bits of meat or other food held before them, the young adults manifested less eagerness for food and less regularity in their feeding reactions than did the larvae.

On July 26, a large number of late larvae and young adults of the larger type were brought into the laboratory. Twenty animals, including young adults and larvae which had almost attained the adult condition, were retained for experimental study. During several days following July 26 none of them manifested any interest in food. On August 3 nearly all of them manifested hunger by promptly seizing and eating crayfish's meat held before them or of approaching bits of it held some distance from them.

Like the late larvae, the young adults demonstrate an "approaching" and a "seizing" reaction. Sometimes they exhibit a type of reaction which might be interpreted as the "nosing" reaction described by Copeland in *Diemyctylus viridescens.* More commonly, however, the seizing reaction follows the approaching reaction without an intervening pause. On the other hand, many of the animals would at times attempt to seize objects held close to them without first manifesting an approaching reaction even though they would not approach an object held a short distance from them. When the seizing reaction is not preceded by the approaching reaction an initial response similar to the nosing reaction may be observed in some instances, while in others the seizing reaction is apparently the initial response.

Obviously the sense of sight is an important factor in these reactions; however, that the olfactory sense also plays an important part in the feeding reactions is demonstrated by the following observations. A packet of gauze containing a bit of crayfish's meat and another containing a small piece of rock were suspended by threads in the presence of several of these hungry animals. They promptly seized the packet containing the crayfish's meat as often as it was presented, but made no attempt to seize the other packet. Two packets of gauze, one of which contained frog's meat, the other dry cotton, were now suspended by threads in the presence of the same animals. They promptly seized the packet containing the frog's meat as often as it was presented, but did not seize the other packet. Obviously the capacity to discriminate between the edible and inedible objects in these experiments involved the olfactory sense.

It may be noted in passing that these animals do not always discriminate thus clearly between edible and inedible objects. Some of them did at times approach and seize inedible objects which emitted no odor. After repeated attempts following the presentation of food a few animals were induced to seize pledgets of cotton. In at least one instance such a pledget of cotton was also swallowed.

In order to determine more accurately the relative importance of the sense of sight and the olfactory sense in the feeding reactions several hungry animals were rendered sightless by enucleation of their eyes, while several others were subjected to an operation under ether anesthesia in which the anterior portion of the cranial cavity was laid open and the olfactory nerves were severed. The former operation caused the animals little apparent discomfort. The latter was more severe; however, all but one of the animals recovered promptly. Both the de-eyed animals and those which had recovered after resection of the olfactory nerves took food on the day following the operations and were not less active than the unoperated animals.

When small pieces of crayfish's meat were held before the de-eyed animals they promptly seized and ate them. They even followed pieces of crayfish's meat moved before them. When inedible objects which emitted no odor were held before them they did not react unless the objects were in actual contact with them. In such instances they would sometimes attempt to seize them just as normal animals sometimes attempt to seize inedible objects which come close to or in contact with them. The de-eyed animals reacted essentially in the same manner on successive days as long as they were kept under observation. Obviously their ability to discriminate between edible and inedible objects involved the olfactory sense.

When pieces of crayfish's meat or other food were held before the animals whose olfactory nerves were severed, they were promptly seized and eaten. When inedible objects were presented in the same manner they were seized just as promptly.

If they could be swallowed without difficulty they were promptly swallowed, otherwise they were discarded after an attempt to swallow them. These animals would seize and swallow pledgets of cotton quite as promptly as pieces of meat regardless of whether or not the pieces of meat and the pledgets of cotton were concealed in packets which were similar in appearance. Obviously these animals did not discriminate between food and inedible objects. Inasmuch as the de-eyed animals did discriminate between edible and inedible objects the conclusion that such discrimination is accomplished primarily by the olfactory sense is warranted.

Attempts to demonstrate a sense of taste in these animals resulted negatively. Obviously it would be quite impossible to differentiate between the manifestations of an olfactory and a gustatory sense in normal animals. However, if animals in which the olfactory nerves are severed should react to the fluid extracts of food introduced into their mouths such reactions might be interpreted as the manifestations of a gustatory sense. Accordingly aqueous extracts of frog's meat and crayfish's meat were introduced into the mouths of the animals whose olfactory nerves were severed, but no reactions were elicited.

The results of the foregoing experiments on *Ambystoma tigrinum*, in so far as they bear upon the relative importance of the sense of sight and the olfactory sense in the feeding reactions, agree in general with the results of Copeland's experiments on *Diemyctylus viridescens.*

SUMMARY

The typical response of the larvae of *Ambystoma tigrinum* to the presence of food consists in an "approaching" and a "seizing" reaction. Young adults frequently exhibit also a "nosing" reaction. The "approaching" reaction is commonly a visual response. The "nosing" and "seizing" reactions, except when the latter follows the "approaching" reaction more or less spontaneously, involve the olfactory sense.

Moving objects are detected and pursued more promptly than objects which are not in motion.

In the absence of sight food is detected by the sense of smell. Discrimination between edible and inedible objects also depends on the olfactory sense.

RESPONSES OF THE DE-EYED LARVAE OF AMBYSTOMA TIGRINUM (GREEN) TO SOLID BODIES

By Albert Kuntz and José Zozaya
St. Louis University School of Medicine

While studying the feeding reactions of de-eyed larvae of *Ambystoma tigrinum*, a characteristic reaction was observed when the forceps were brought near the head in the water when no food was present. As the forceps approached from the side the animal would turn its head in that direction. It would then resume a position of rest or move slowly backward or forward. Sometimes it would attempt to seize the forceps as soon as their presence was detected.

In the further study of these responses the forceps which were used for handling food were discarded and a clean glass rod and other clean objects were used. A number of larvae which had been de-eyed three days previously, were placed in a shallow circular aquarium either singly or in groups of two or three and allowed to remain undisturbed until they became relatively quiet before observations were begun. As the glass rod was slowly and carefully brought near the head from either side the animal responded by turning its head toward the rod when it was still 5 mm. or farther distant. Sometimes the reaction occurred when the rod was still 20 mm., or farther, from the head. When the rod approached from above, the head was elevated; when it approached from below, the head was depressed. The reaction was essentially the same whether the rod approached the head at the level of the base of the gills or nearer the anterior end. In some instances the movement of the head toward the rod was the only response elicited; in other instances, after turning the head toward the rod, the animal would swim slowly backward or forward. Occasionally it would attempt to seize the rod as soon as the head was turned toward it. All the larvae used in the initial experiments responded to the near

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approach of the glass rod to the head essentially in the same manner, though not with equal promptness and precision. Neither could this response be elicited when the animals were reacting to other stimuli.

Further experiments were made in an attempt to discover whether similar responses could be elicited by bringing the glass rod into proximity with other parts of the body. The majority of these experiments resulted negatively. However, several of the larvae sometimes reacted in a very definite manner when the glass rod approached the lateral surface of the anterior portion of the trunk. The initial response consisted in the contraction of the segmental muscles of the trunk on the side stimulated, which resulted in an appreciable curvature of the body. Following this the animal would swim slowly forward. The response could not be elicited except when the animal was relatively undisturbed by other stimuli. Neither was it entirely constant under these conditions. The area just posterior to the base of the gills proved to be the most sensitive area of the trunk. When the response was elicited by the near approach of the glass rod to this area not only did the characteristic contraction of the segmental muscles take place, but the gills were also adducted. All attempts to elicit a response to the near approach of the glass rod to the tail resulted negatively.

The glass rod used in the above experiments was 4 mm. in diameter and rounded at the end. Clean glass tubes of smaller diameter were used with essentially the same results. When a galvanized steel wire 2 mm. in diameter was used the animals responded somewhat more vigorously than when the glass rod was used. Apparently the galvanized wire afforded a somewhat stronger stimulus than the glass rod. Other objects used as stimulating agents were a dissecting needle, a fine steel wire, a bone needle holder 6 mm. in diameter, rods of pine wood 6 mm. or less in diameter, and pieces of soft rubber tubing. The animals responded to the near approach of all these objects essentially in the same manner, but somewhat less vigorously to the bone, wood, and rubber objects than to the glass rod.

Five of the de-eyed larvae used in the initial experiments were kept in the laboratory and subjected to further experimentation at irregular intervals. Whenever the experiments were made under favorable conditions the larvae responded to the near approach of the glass rod, or other solid bodies, in the characteristic manner. In the course of a week four of these larvae entered the final phase of their metamorphosis. As they became less active and sought to leave the water they no longer responded to the near approach of solid bodies. The remaining de-eyed larva was kept under observation in the laboratory for a period of three weeks. It did not fail to respond in the characteristic manner to the near approach of the glass rod or other solid objects, whenever the tests were made in the absence of conflicting stimuli. Other larvae, taken from another pond and de-eyed later, responded in the same manner to the near approach of solid objects one hour after the eyes were removed as well as on successive days following the operation. All attempts to elicit responses of the same type from young adults and larvae which were passing through the final phase of their metamorphosis resulted negatively.

When a solid body approaches the head of a normal seeing larva in the water the reaction which takes place, doubtless, is mediated through the sense of sight. If the animal is hungry it may attempt to seize an approaching glass rod as it would a bit of food. On the other hand, if no feeding reaction is elicited the response which takes place is usually an effort to avoid contact with the object. Doubtless the normal seeing larvae have the same capacity to detect the presence of solid bodies in close proximity with their skin by some sense other than sight as the de-eyed larvae, but stimuli received through the eyes result in motor responses more promptly than those received from nearby solid bodies by receptors in the integument.

Larvae with only one eye removed responded essentially in the same manner as the de-eyed larvae when a solid body approached the head from the eyeless side in such a manner that its presence could not be detected by the intact eye. No response was elicited from these larvae by the near approach of a solid body to the lateral surfaces of the trunk, or any part of the body except the head.

A comparison of the responses of the de-eyed larvae of *Ambystoma tigrinum,* described above, with the responses of certain blinded fishes to the near approach of solid bodies in the water, is not without interest. Parker and Van Hausen ('17) described the responses of the catfish (*Amiurus nebulosis*) to metallic and non-metallic rods. The only non-metallic rod to the near approach of which these fishes responded when deprived of their sight in the experiments of Parker and Van Hausen, was a rod of cedar wood. This response, as suggested by these authors, was mediated through the sense of smell. Crozier ('18) described the responses of the de-eyed hamlet (*Epinephelus striatus*) to the near approach of rods of various metals and woods as well as such miscellaneous substances as glass, hard and soft rubber, porcelain, hard paraffin, sandstone, and compressed carbon.

According to Parker and Van Hausen the blindfolded catfishes usually responded to a metallic rod approaching them in the water by swimming away when it was still some centimeters distant. However, if but a small portion of the metal was in contact with the water they sometimes responded by moving toward the rod and even nibbling at it. According to Crozier, when a glass rod approaches the head of a de-eyed hamlet to within 4.5 or 5 cm. "the fish bends in the opposite direction and swims slowly backward; or it may back deliberately away for 10 or 15 cm., then abruptly turn away from the side stimulated and assume a position at right angles to that held before being stimulated." He noted also that when the rod approached the caudal peduncle the first response of the tail was to bend toward the opposite side. The initial reaction in these responses as in the characteristic responses of the catfishes to the near approach of a metallic rod is an avoiding reaction; consequently it is negative in character. On the other hand, the initial reaction in the typical response of the de-eyed larvae of *Ambystoma tigrinum* to the near approach of a solid body to the head is a movement toward that body; consequently, it is positive in character. Parker and Van Hausen have demonstrated conclusively that the responses of the blinded catfishes to the near approach of metallic rods in the experiments described by them were stimulated by electrical currents generated on the rods in contact with the water. They have shown also that a positive reaction, i. e., a movement toward the rod, occurs only when the stimulus is very weak. Inasmuch as the de-eyed hamlets in Crozier's experiments, like the de-eyed larvae of *Ambystoma tigrinum* in the experiments described in this paper, responded not only to metallic rods but also to non-metallic bodies on which an appreciable electrical current could not be generated by contact with water, these responses can not be the results of electrical stimulation. As suggested by Crozier, mechanical deformations in the water probably constitute the stimulus involved. The de-eyed hamlets used in Crozier's experiments responded to the approach of solid bodies at greater distances and more vigorously than the larvae of *Ambystoma tigrinum* used in the experiments described in this paper. Furthermore, the initial reaction in the characteristic responses of the former was negative, while that of the latter was positive in character. Doubtless this difference is due to the fact that the receptors involved were stimulated more strongly in the hamlets than in the larvae of *Ambystoma.* Obviously the form of sensitivity involved, which is epicritic in character, is less highly developed in *Ambystoma tigrinum* than in fishes like *Epinephelus striatus.*

The above experiments were carried out at the Iowa Lakeside Laboratory during the summer of 1920. The writers desire to express their indebtedness to Professor R. B. Wylie, Director, for the opportunity of working at the Laboratory and for his interest in furthering the work.

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NEST DIGGING AND EGG LAYING HABITS OF BELL'S TURTLE

CRYSEMYS MARGINATA BELLII (GRAY)

By Frank A. Stromsten
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During the summer of 1921 some forty or fifty Bell's painted turtles dug their nests on the side of a small hill just north of the Iowa Lakeside Laboratory. This afforded an excellent opportunity for the study of the nest-digging and egg-laying habits of this species which is so abundant around the Okoboji lakes. When the turtle is digging her nest or depositing her eggs she is not easily frightened, so that it is possible to get very close to the animal and with a flash light held within an inch or so of the body every movement may be easily studied. On several occasions a number of the students at the Laboratory were able to watch the entire process from the time the turtle landed on the shore until she returned to the water again. The following description taken from my field notes of June 30, 1921, on nest 40 is typical.

A painted turtle measuring about six inches in length appeared at the water's edge at about 8:00 p. m., about sixty feet from where the writer was waiting. She followed an old cow-path up the rather steep slope of the hill for a distance of about thirty feet and then turned at right angles to the path and came directly towards me. After she had traveled for perhaps fifteen feet she stopped and dug into the hard dry clay, first with the right hind foot and then with the left, making the dust fly for a considerable distance. It was only twice, once for the right and then for the left foot, that I could see the dust fly although the animal still continued to dig. She began digging her nest at 8:17 p. m. I gradually approached to within five or six feet of the turtle. This disturbed her slightly, but she soon resumed her operations. At first she inserted one foot into the depression she had started and made four or five dig-

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ging or scraping motions much as a person would in trying to dig a hole in the ground with his finger nails. She then lifted the dirt out and pushed it as far back from the hole as she could, at the same time shifted her body so that the cloaca was directly over the pit and softened the hard clay with water from her bladders. The water was squirted into the pit with considerable force. Then the body was moved further so that the other foot could be thrust into the hole and she continued to dig as before. This was kept up, first with one foot, then softening the dirt, then with the other foot, for some time. This continuous wetting of the dirt soon made it of about the same consistency as thick cream, at which time she discontinued wetting it. As the dirt began to get dryer she commenced to enlarge the diameter of the hole at the bottom so as to make the nest flask-shaped, the neck being slightly larger than the leg and the spherical body as large as the reach of the leg would permit. In digging the body of the nest the turtle would scrape the sides with her claws three or four times, then press the dirt against the pad of her foot with her claws and carry it out by the handful. It was deposited near the edge of the opening and then pushed out so that the dryer dirt was left near the opening while the soft mud was pushed to the periphery. It took about one hour and thirty minutes for this turtle to complete the digging of her nest from the time she began.

At 9:47 the turtle began to deposit her eggs. First she inserted her right hind foot into the nest, moved over so that the cloaca was directly over the opening, and then removed her leg from the nest. The egg was deposited so that it rested slightly on the edge of the opening, and gently slipped into the nest. Immediately the turtle inserted her right foot again and apparently placed the egg to one side of the nest. In about another minute a second egg was deposited and placed in the same manner as the first. It took about one-half second for the egg to pass out of the body, and seemed to involve no undue effort on the part of the turtle. The third egg appeared in about thirty seconds, and thirty seconds later, the fourth. The fifth egg did not appear until a minute and a half later, although two unsuccessful efforts were made at the regular intervals of half a minute. The sixth egg appeared on schedule time in thirty seconds. The sixth was the last one laid at this time, but evidently the effort had been made to lay eight or nine. After each egg was laid it was arranged in the nest by the right hind foot. The process of egg-laying was completed at 9:52, so that the entire process took about five minutes and at intervals of about thirty seconds for each egg.

Immediately the turtle began pulling dirt in from the edges, the dryer dirt going in first. This was pressed down by the hind foot, first dirt from one side and then the other was pulled in, each foot being used alternately. She seemed to press the dirt down with her knuckles much as we might with a loosely closed fist. The wet dirt was the last to be pulled on the nest. The softer mud on top was thoroughly kneaded by the knuckles, and flattened and packed by rubbing the plastron over it. Dry dirt was then scratched in, and grass roots were either accidentally or purposely kneaded in as though transplanted. It almost seemed to the observer that the turtle made a special effort to reach far out for bits of grass and debris to help conceal her nest. When this was completed the turtle appeared startled at our flash light for the first time. It was as though she had awakened from a trance. She stretched out her neck, looked around for an instant and then hurried away towards the lake. It was 10:23 P. M. when she left the nest, so that the entire process of nest-digging and egg-laying took over two hours. She worked quite vigorously most of the time, but towards the end she appeared tired and needed to rest frequently. On another occasion we found that during the last fifteen or twenty minutes of work in concealing the nest the turtle at first worked pretty regularly for about fifty seconds and rested ten to twelve seconds, and that later the periods of work were shortened and the rest periods became longer. At no time during the procedure of nest-digging and egg-laying did the turtle seem much disturbed by the presence of three or four observers, even when the flash light was held directly in front of her.

In the case of one turtle, Professor Larrabee of Yankton held his flashlight in front of her after she had left the nest to return to the lake. This seemed to produce a sort of hypnotic effect, for she would follow this light whichever direction it was moved, up hill or down hill, faster or slower.* If the light was hidden she would start for the lake, but when the light was produced again she would follow it. However, when she was allowed to get within a few feet of the water the light no longer had any fascination for her; she hurried away into the water and disappeared from view.

The number of eggs laid in one clutch varied from six to thirteen. The eggs are oblong, measuring from 1.5-2 cm. in the short diameter to 2.5-3 cm. in length, and weigh from 7-12 grams. When first laid they are somewhat translucent and pinkish but later become white and opaque, less turgid and somewhat more brittle. The nests are dug out and the eggs eaten by some night prowler. One night after a rain some twenty out of forty nests were robbed, even though some of the nests had been protected by covering them with flat stones. The writer has not yet been able to determine exactly the identity of the culprit, but on one hillside he counted more than seventy nests that had so been robbed, and on another a hundred ten nests were dug up and shells strewn around.

The writer wishes to acknowledge the assistance of Miss Pauline Kimball, Miss Esther Lusted, and Professor Austin P. Larrabee in taking notes and watching the time.

* At times when she was following the light rapidly up hill she appeared to be panting.

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REPORT ON THE ANTS

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

WILLIAM MORTON WHEELER
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Although there has been considerable collecting of ants on the Windward Islands, only the species of St. Vincent and Grenada have been listed hitherto. Professor Dayton Stoner has recently sent me the ants which he collected as entomologist of the Barbados-Antigua Expedition of the University of Iowa, and during July, 1920, I was able to collect on both of the islands while on my way to British Guiana. Owing to the protracted and almost unprecedented drought, however, I was unable to secure many species. The following list is based on these small collections, on material that has been accumulating in my cabinet and on that collected by Professor A. Forel in Barbados while on his journey to Colombia in 1896. The total is rather meager and most of the species are well-known, widely distributed West Indian forms.

Family **Formicidæ**

Subfamily **Ponerinæ**

Platythyrea punctata F. Smith var. *pruinosa* Mayr.—Barbados. First taken on the island by Professor Forel. Professor Stoner captured two workers.

Odontomachus hœmatoda L. subsp. *insularis* Guérin.—Antigua: St. John (Stoner; Amer. Mus. Exped.) ☿ ♀. Barbados (Forel, Stoner) ☿. Bridgetown (Wheeler) ☿. This ant is common throughout the West Indies and tropical Florida. To the many known localities I may add Montserrat and St. Kitts, from which I have received workers taken by Mr. H. A. Ballou.

Subfamily **Myrmicinæ**

Cardiocondyla emeryi Forel.—Male and female specimens recorded by Forel from Barbados and Guadeloupe. The species was first found on St. Thomas but has since been taken in many widely separated localities: Madeira, Syria, East Indies, Madagascar, Florida, etc.

Monomorium minutum Mayr.—Barbados (H. A. Ballou) ☿ ♀ ♂. The specimens are very close to if not identical with the typical form of the species from Southern Europe. There can be little doubt that this, like the following Monomoriums, has been introduced into the islands by commerce.

Monomorium carbonarium F. Smith subsp. *ebeninum* Forel.—Antigua: St. John (Stoner) ☿.

Monomorium floricola Jerdon.—Barbados (Forel).

Monomorium (Parholcomyrmex) destructor Jerdon.—Antigua: St. John (Stoner, Wheeler) ☿. I took this ant on the flowers of a Bignoniaceous tree in the botanical garden. Introduced from the Indomalayan Region.

Monomorium (Xeromyrmex) salomonis L. subsp. *subopacum* F. Smith.—Antigua: St. John (Wheeler) ☿. Running on logs near the wharves. Evidently introduced from Spain or North Africa.

Solenopsis geminata Fabr.—Antigua (Amer. Mus. Exped.) ☿; Barbados (Forel, H. A. Ballou), Bridgetown (Wheeler) ☿.

Pheidole fallax Mayr subsp. *jelskii* Mayr var. *antillensis* Forel, ♃ ☿.—Antigua (Stoner) ☿: St. John (Amer. Mus. Exped.) ☿. Barbados (Forel, Stoner) ♃ ☿. Also recorded by Forel from Guadeloupe and common on many other West Indian Islands.

Pheidole subarmata Mayr var. *elongatula* Forel.—Barbados (Forel) ♃ ☿.

Crematogaster (Orthocrema) brevispinosa Mayr var. *brevidentata* Forel.—Barbados: Bathsheba, 200 m. (Forel) ☿.

Crematogaster (Orthocrema) brevispinosa Mayr var. *minutior* Forel.—Barbados: Bridgetown (Wheeler) ☿, running on tree-trunks.

Crematogaster (Orthocrema) carinata Mayr.—Barbados: Bridgetown (Wheeler) ☿; nesting in the bark of living trees. This species was originally described from Brazil, whence it may have been introduced into Barbados. The specimens agree perfectly with Mayr's description and figures in his work on the ants of the Novara Expedition.

Crematogaster (Orthocrema) steinheili Forel. — Barbados (Forel) ☿ ♀ ♂.

Triglyphothrix striatidens Emery.—Barbados (W. G. Jeffreys) ☿. Cited by Forel. This species is of recent importation from the Old World tropics.

Wasmannia auropunctata Roger.—Barbados (Forel) ☿ ♂.

Atta columbica Guérin var. *lutea* Forel.—Barbados (W. G. Jeffreys) ☿. Originally described from the island in 1893, but seems not to have been taken since.

Subfamily **Formicinæ**

Brachymyrmex cordemoyi Forel.—Taken by Forel in Barbados and Guadeloupe. Originally from the Argentine, this minute ant is becoming tropicopolitan. Forel has also recorded it from the Seychelles.

Brachymyrmex heeri Forel subsp. *obscurior* Forel.—Barbados and St. Lucia (Forel) ☿ ♂; Bridgetown (Wheeler) ☿ ♀.

Prenolepis (Paratrechina) longicornis Latr.—Antigua: St. John (Stoner) ☿; Barbados: Garrison (W. Norwell) ♀; Bridgetown (Wheeler) ☿ ♀.

Prenolepis (Nylanderia) vividula Nyl. var. *antillana* Forel.—Barbados (Forel).

Camponotus (Myrmosphincta) sexguttatus Fabr.—The finding of a new and beautiful color variety of this variable species among the specimens collected by Professor Stoner in Antigua has led me to revise the materials in my collection, with the following results:

Camponotus (Myrmosphincta) sexguttatus (typical). Fabricius' types were from St. Croix Island. I have seen no specimens from this precise locality, but considerable material in my collection from St. Thomas (Morrison), Porto Rico and Culebra Island (Wheeler), and Desecheo Island (F. E. Lutz) is very probably typical. Emery synonymizes the *C. ruficeps* Fabr. (female) from the Essequibo River with the previously described *sexguttatus* (worker), and I have taken colonies at Kartabo and Kalacoon, British Guiana, which must be very near the type-locality of *ruficeps.* I have before me also series of specimens from St. Vincent (E. O. Hovey), Bridgetown, Barbados (Wheeler), Castries, St. Lucia (E. O. Lutz, Wheeler, J. C. Bradley); Dominica (Lutz, Wheeler), Fort de France, Martinique (Forel, Wheeler); San Lorenzo, Sanchez and San Francisco Mts., Santo Domingo (Busck); Corrozal, Panama (Wheeler); Nicaragua (W. Fluck), etc. I believe that Emery is right in treating *C. bimaculatus* F. Smith as a mere synonym of *sexguttatus* (typ.). There is considerable variation in the maculation of the gaster in workers from the same colony, and in minor individuals the spots are usually developed only on the second segment. The type of *bimaculatus* is from St. Vincent. What Forel has designated as var. *bimaculatus* from Brazil and Paraguay is, in my opinion, var. *fusciceps* Emery, which is not known to occur in the West Indies, though I have specimens of it from Kaieteur, British Guiana (F. E. Lutz). I received numerous workers, females and males from Fiebrig, who collected them on the Parana River, Paraguay. It is probably a part of this series which was identified as *bimaculatus* by Forel. The var. *fusciceps*, however, has the head of the female and major worker black with its anterior portion and the mandibles dark brown or castaneous, and not yellowish red as in the West Indian form described by Smith.

Camponotus sexguttatus var. *grenadensis* Forel.—This variety was originally described from the island of Grenada, but Forel found it also in Barbados and it has been taken in the same locality by Jeffreys and Stoner. I have specimens of all three phases taken in Grenada by Professors Roland Thaxter and C. T. Brues. The variety is easily recognized by its color, the head, thorax and petiole of the worker and female being light yellowish red. The paired ivory-colored spots on the black or dark brown gaster are well-developed. The wings of the female are more yellowish and the pterostigma paler than in the typical *sexguttatus*. The male is dark brown with the dorsal surface of the head and thorax and the articulations of the legs and gaster testaceous. As in other varieties the second gastric segment has a couple of narrow transverse, pale spots at its base. The wings are scarcely paler than in the male of the typical form.

Camponotus sexguttatus var. *antiguanus* var. nov.

Worker major and minor. Clear reddish yellow throughout, except the mandibles and antennæ which are red, and a large poorly defined ivory white spot on each side of the second gastric segment.

Male. Brownish yellow; antennæ and legs pale brown; petiole and gaster darker, the latter with pale borders to the segments and a pair of whitish, transverse spots at the base of the second segment.

Seven workers and a single male taken on Antigua by Professor Dayton Stoner. Among the materials in my collection I find also the three following undescribed forms:

Camponotus sexguttatus var. *montserratensis* var. nov.

Worker and female. Colored like the preceding variety but lacking the pale spots on the second gastric segment. The wings and their veins in the female are very yellow, the pterostigma brown.

Male. Resembling the male of *antiguanus,* but the funiculi, legs and petiole are yellow like the head and thorax. Wings colord as in the female.

Described from six workers, two females and three males taken on the Island of Montserrat, June 19, 1912, by Mr. H. A. Ballou, "on a sour-sop tree."

Camponotus sexguttatus var. *unitæniatus* var. nov.

Worker. Dark brown; the spots on the second gastric segment fused to form a broad white fascia, usually indented in the middle behind, those on the third segment transverse and rather large but not confluent, those on the first segment small. The worker major has the head entirely brownish yellow and decidedly opaque.

Several workers from Chaquimayo, Peru, collected by Prof. Nils Holmgren (Stockholm Museum).

Camponotus sexguttatus subsp. *basirectus* subsp. nov.

Worker minor. Differing from the typical *sexguttatus* as follows: the head is more narrowed and dorsally more depressed at the occiput, the thorax is longer and more slender, epinotum more elongate, with its base in profile straight and the mesoëpinotal constriction much shorter and shallower, the epinotum more elongate, with its base in profile straight and horizontal, nearly twice as long as the declivity and meeting it at a distinct though obtuse angle. The gaster is decidedly larger and more elongate, the legs and antennæ more slender. The surface of the body and especially of the head is more opaque and somewhat more sharply shagreened. The hairs are distinctly longer and more abundant on the body. The color is dark reddish brown, the legs yellowish brown; the spots on the first to third gastric segments ivory yellow, very large, those on the first and second segments rather rounded and almost meeting in the middle line.

Described from several specimens taken by H. Mosén in Brazil and lent by the Stockholm Museum. This may be a distinct species, but I attach it provisionally to *sexguttatus* as I have seen only minor workers.

The following table may serve to identify the workers of the various described varieties and subspecies of *sexguttatus*.

1. Epinotum in profile convex and arcuate above.
   Bolivia .... subsp. *biguttatus* Emery
   Epinotum in profile straight or more or less depressed above .... 2.

2. Mesoëpinotal impression feeble; epinotum long, its base in profile straight and horizontal, forming a distinct angle with the declivity.
   Brazil .... subsp. *basirectus* subsp. nov.
   Mesoëpinotal impression deeper; epinotum shorter, its base in profile high in front, sloping backwards and not forming a distinct angle with the declivity (subsp. *sexguttatus* Fabr.) .... 3.

3. At least the gaster dark brown or black .... 5.
   Gaster as well as head and thorax yellowish red .... 4.

4. Gaster with cream-colored spots on second segment.
   Antigua .... var. *antiguanus* var. nov.
   Gaster immaculate. Montserrat.......... var. *montserratensis* var. nov.

5. Head, thorax, petiole and appendages yellowish red.......... 6.
   At least the thorax dark brown or black.......... 7.

6. Spots on the first and second gastric segments fused to form fasciæ.
   Peru .... var. *albotæniolatus* Fabr.
   Spots on the gaster not fused to form fasciæ. Grenada.
   Barbados .... var. *grenadensis* Forel

7. Spots on at least one of the gastric segments confluent and forming fasciæ .... 8.
   Spots on the gastric segments not confluent.......... 9.

8. Only the spots of the second gastric segment confluent.
   Peru .... var. *unitæniatus* var. nov.
   The spots of the first, second and third segments confluent to form fasciæ. Bolivia .... var. *ornatus* Emery

9. Antennal scapes in female and worker major surpassing the head by a little more than ¼ their length; hairs on posterior tibiæ a little longer than the diameter of the tibiæ .... 10.
   Scapes longer, surpassing the occiput by 1/3 their length; funicular joints longer; hairs on the posterior tibiæ a little shorter than the diameter of the tibiæ. Brazil, Peru.......... var. *decorus* F. Smith

10. Head of female and worker major more or less extensively light red anteriorly; sometimes the whole head is yellowish red; spots present in female on first to fourth gastric segments; worker major often with spots on first and third as well as on the second segment; worker minor usually with spots only on the second segment. West Indies, Central America, Guiana..........................*sexguttatus* (typical)

Head of female and worker major dark brown or castaneous anteriorly; female with a pair of large spots on the second and small spots on the first and third segments; major and minor worker with spots only on second segment. Argentine, Paraguay, Bolivia, Brazil, British Guiana..var. *fusciceps* Emery

REPORT ON THE SPIDERS

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

Elizabeth B. Bryant
Museum of Comparative Zoology, Cambridge, Massachussetts

During the spring of 1918 Dr. Dayton Stoner of the University of Iowa collected some spiders at Antigua and Barbados. Many of them are forms common throughout the West Indies and South America, but six have been found to be new species. A few immature specimens cannot be identified, and three specimens which are represented by only one sex have been left with only a generic determination. Of the twenty-nine species of spiders, nine families are represented. The Argiopidæ has nine species, the Clubionidæ six, the Salticidæ four, and the other families are represented by but one or two species each.

The types have been placed in the Museum of Comparative Zoölogy at Cambridge and the paratypes and remainder of the collection in the Zoölogical Museum at the University of Iowa.

Very few spiders have been collected at either Antigua or Barbados. In 1878 Becker described *Lycosa (Tarentula) beckeri* and two years later Keyserling described from the same collection *Sparassus antiguensis,* a spider that since has been found at Hayti and Porto Rico.

The arrangement in families and genera follows Simon's "Histoire Naturelle des Araignées" and Petrukevitch's "Index-Catalogue of Spiders of North, Central, and South America," American Museum of Natural History, Bulletin 29, 1911, except the Walckenaer names based on Abbot's unpublished drawings.

Order ARANEIDA

Family **Aviculariidæ**

Cyrtopholis bartholomei (Latreille)

1832. *Mygale bartholomei* Latreille, Nouv. ann. museum, Vol. 1, p. 69.

1879. *Crypsidromus gypsator* Becker, Ann. soc. ent. Belgique, Vol. 22, p. 85.
1903. *Cyrtopholis venatorius* Simon, Hist. nat. araignées, Vol. 2, p. 931.

Antigua. Reported from several islands in the West Indies.

Family **Sicariidæ**

Scytodes fusca Walckenaer

1837. *Scytodes fusca* Walckenaer, Ins. aptères, Vol. 1, p. 272.
1873. *Scytodes guyanensis* Taczanowski, Hor. soc. ent. Ross, Vol. 10, p. 108.

Antigua. A common house spider in the West Indies.

Family **Pholcidæ**

Physocyclus globosus (Taczanowski)

1873. *Pholcus globosus* Taczanowski, Hor. soc. ent. Ross, Vol. 10, p. 105.
1893. *Physocyclus globosus* Simon, Hist. nat. araignées, Vol. 1, p. 470, fig. 457.

Antigua. A common house spider in Central America, West Indies, and southern United States.

Family **Argiopidæ**

Tetragnatha antilliana Simon

1897. *Tetragnatha antilliana* Simon, Proc. Zool. Soc. London, p. 868.

Barbados. Found in the West Indies and Central America.

Prionolæma gracilis, sp. nov.

Plate I, figs. 1-3

♂ total length 5 mm. ♀ total length 6 mm.

♂ Lateral eyes in contact. The fang of the mandible of the male has no cusps; the upper margin of the fang groove with three large teeth at the apex; the lower margin with several small teeth. The tibia of the palpus is one-fourth longer than the patella. The legs have very few spines.

♀ Abdomen gibbous anteriorly. The lower margin of the fang groove has two teeth near the apex. The spines on the legs are very few.

I am not quite satisfied as to the generic position of this species. It agrees with the description of *Prionolæma* Simon, in the position of the lateral eyes, but it is not caudate. It agrees with *Agriognatha* O. P. Cambridge (1896) in the arrangement of the eyes, but it is not caudate and it lacks the single stout spine on the apex of femur II. It agrees with *Cyrtognatha* Keyserling (1881), in the position of the lateral eyes and the shape of the labium. Simon in his key in Hist. nat. araignées, 1894, Vol. I, p. 723, wrongly quotes Keyserling in the shape of the labium.

Antigua. Two males and three females.

Leucauge hortorum (Hentz)

1847. *Epeira hortorum* Hentz, Jour. Boston Soc. Nat. Hist., Vol. 5, p. 477, pl. 31, fig. 19; reprint, 1875, p. 118, pl. 13, fig. 19.
1884. *Argyroepeira hortorum* Emerton, Trans. Conn. Acad., Vol. 6, p. 332, pl. 37, figs. 29-32.

Antigua. Found from Canada to northern South America.

Argiope argentata (Fabricius)

1775. *Aranea argentata* Fabricius, Syst. Entom., p. 433.
1839. *Argiope fenestrinus* Koch, Die Arach., Vol. 5, p. 39, pl. 155, fig. 361.
1893. *Argiope argentata* McCook, American Spiders, Vol. 3, p. 220, pl. 16, figs. 1-2.

Antigua. A tropical and subtropical spider of the western continent from North Carolina south to Patagonia.

Argiope trifasciata (Forskål)

1775. *Aranea trifasciata* Forskål, Desc. Anim., p. 86.
1847. *Epeira fasciata* Hentz, Jour. Boston Soc. Nat. Hist., Vol. 5, p. 468, pl. 30, fig. 8; reprint 1875, p. 107, pl. 12, fig. 8.
1884. *Argiope transversa* Emerton, Trans. Conn. Acad., Vol. 6, p. 330, pl. 34, fig. 20, pl. 38, figs. 15-18.

Antigua. A common spider from Canada to Chili.

Eustala prompta (Hentz)

1847. *Epeira prompta* Hentz, Jour. Boston Soc. Nat. Hist., Vol. 5, p. 472, pl. 31, fig. 4; reprint 1875, p. 112, pl. 13, fig. 4.
1884. *Epeira parvula* Emerton, Trans. Conn. Acad., Vol. 6, p. 317, pl. 34, fig. 12, pl. 37, figs 1-2.

Antigua; Barbados. A common spider in the United States and West Indies.

Eustala fusco-vittata (Keyserling)

1863 (1864). *Epeira fusco-vittata* Keyserling, Sitz. ber. Isis, p. 129, pl. 6, figs 7-8.

1893. *Cyclosa thorelli* McCook, American Spiders, Vol. 3, p. 228, pl. 19, fig. 11.

Antigua; Barbados. South America and the West Indies.

Araneus oaxacensis (Keyserling)

1863 (1864). *Epeira oaxacensis* Keyserling, Sitz. ber. Isis, p. 121, pl. 5, figs. 12-16.

1888. *Epeira vertebrata* McCook, Proc. Acad. Philadelphia, p. 196, figs. 6-10.

Antigua; Barbados. Found in the West Indies, Mexico and on the Pacific coast.

Gasteracantha tetracantha (Linnæus)

1767. *Araneus tetracantha* Linnæus, Syst. Nat., 12th Edition, Vol. 2, p. 1037.

1837. *Plectana linnœi* Walckenaer, Ins. aptères, Vol. 2, p. 163.

1845. *Gasteracantha Quadridens* Koch. Die Arach., Vol. 11, p. 59, pl. 374, fig. 880.

1893. *Gasteracantha pallida* McCook, American Spiders, Vol. 3, p. 209, pl. 14, fig. 8.

Antigua. A small *Gasteracantha* which has been found on several islands of the West Indies and in California.

Family **Clubionidæ**

Heteropoda venatoria (Linnæus)

1767. *Araneus venatoria* Linnæus, Syst. Nat., 12th Edition, Vol. 2, p. 1035.

1837. *Olios antillianus* Walckenaer, Ins. aptères, Vol. 1, p. 568.

Barbados. A cosmopolitan tropical and subtropical spider.

Pseudosparianthus antiguensis sp. nov.

Plate I, fig. 4

♀ total length 17 mm.

Cephalothorax, legs, and mandibles orange yellow, the former with many small black bristles; sternum, mouth parts, and coxæ somewhat paler. Abdomen pale grayish yellow without markings, thickly covered with small dark bristles. Anterior row of eyes slightly procurved, medium eyes largest and nearer each other than to the laterals. Posterior row of eyes procurved, the lateral slightly larger than posterior medium, the posterior medium slightly nearer each other than to the laterals. Abdomen twice as long as broad, attenuate behind; the spinnerets borne on a small jointed projection. Upper margin of mandible with three distinct teeth. Tibiæ I and II, 2-2-2, robust spines beneath. Metatarsi I and II with a sub-basal pair of long spines beneath. Metatarsi and tarsi I, II, and III densely scopulate. Vulva wider than long.

This spider does not agree with the description of *Stasina* or *Pseudosparianthus*, but it agrees with *Pseudosparianthus variabilis* Cambridge and *Pseudosparianthus cubana* Banks in having but one pair of spines under the anterior metatarsi, but differs from both in the shape of the vulva and in its much greater size.

Antigua. One female.

Chiracanthium inclusum (Hentz)

1847. *Clubiona inclusa* Hentz, Jour. Boston Soc. Nat. Hist., Vol. 5, p. 451, pl. 23, fig. 18; reprint 1875, p. 85, pl. 10, fig. 18.

1890. *Chiracanthium viride* Emerton, Trans. Conn. Acad., Vol. 8, p. 184, pl. 5, fig. 12.

Antigua; Barbados. Found from Canada south to Central America and West Indies.

Aysha tenuis (L. Koch)

1866. *Anyphæna tenuis* L. Koch, Fam. Drassiden, p. 211, pl. 9, fig. 140.

1897. *Aysha tenuis* Simon, Proc. Zool. Soc. London, p. 879.

Antigua; Barbados. Found on San Domingo, Hayti, Porto Rico, and St. Vincent.

Syrisca keyserlingi Simon

1887. *Teminius insularis* Keyserling, Verh. Zool. Bot. Ges. Wien, Vol. 37, p. 422, pl. 6, fig. 1.

1897. *Syrisca keyserlingi* Simon, Hist. Nat. araignées, Vol. 2, p. 129. (*insularis* preoccupied by Lucas.)

Barbados. Found on Hayti and Cuba.

Family **Lycosidæ**

Sosippus insulanus sp. nov.

Plate I, fig. 5

♀ total length 11 mm.

Cephalthorax dark brown with a pale submarginal band and a central light band narrowing between the posterior row of eyes, dilate in the cephalic area and narrowing in the thoracic part and having a pair of narrow longitudinal dark lines in the dilated portion. Abdomen with a central dark area anteriorly, followed by the usual herring bone markings; ventral area light. Legs with very faint traces of brown. Vulva small.

Barbados. One female.

Lycosa sancti-vincenti Simon

1897. *Lycosa sancti vincenti* Simon, Proc. Zool. Soc. London, p. 888.

Antigua. One female. Found only on St. Vincent.

Family **Oxyopidæ**

Oxyopes salticus Hentz

1845. *Oxyopes salticus* Hentz, Jour. Boston Soc. Nat. Hist., Vol. 5, p. 196, pl. 16, fig. 10; reprint 1875, p. 47, pl. 6, fig. 10.

1876. *Oxyopes gracilis* Keyserling, Verh. Zool. Bot. Ges. Wien, Vol. 27, p. 698, pl. 2, figs. 63-64.

Antigua; Barbados. A common spider south and west of New York, in the West Indies and Central America.

Oxyopeidon maculipes sp. nov.

Plate I, fig 6

♀ total length 4½ mm.

Cephalothorax yellowish-brown, darkened on the sides and reddish between the eyes. Clypeus and sides with many lanceolate white scales. The eyes are about equal distances apart; the anterior medium very much smaller than the laterals, which are placed a little below them. The eyes of the posterior row, subequal and much smaller than the anterior laterals; the posterior medium eyes are hardly twice as far apart as from the laterals; the posterior laterals are at an equal distance from the anterior laterals and posterior medium. The abdomen is grayish with light areas on each side and faint light markings behind. The legs are yellowish, the anterior pair are missing; the others are marked with dark as follows; a spot under the middle of femora II, at basal end of tibia II and tip of tibia III, at tip of femora IV and at base of tibia IV. The vulva is very similar to *Oxyopeidon lætum* Cambridge.

Antigua. One female.

Family **Salticidæ**

Wala vernalis (Peckham)

1893. *Anoka vernalis* Peckham, Proc. Zool. Soc. London, p. 701, pl. 62, fig. 9.

Antigua; Barbados. A common spider in the West Indies.

Cyrene gratiosa sp. nov.

Plate II, figs. 1-2

♀ total length 7 mm.

The cephalothorax is dark brown with scattering white hairs about the eyes and a marginal stripe of white on the sides. The clypeus is covered with thick white hairs. There is a narrow stripe of white scales extending from the posterior eye row to within a short distance of the posterior margin of the thorax. The abdomen has a basal band of white across the anterior end and a narrow central white spot extending to the middle of the abdomen. The posterior part has the common herring bone markings. The sternum is nearly twice as long as wide, slightly narrowed in front, and is constricted into a short truncate lobe between the posterior coxæ. The venter is pale with rows of dark spots. The legs are light with slight indications of markings at the ends of some of the joints. Tibiæ I and II with 2-2-2 spines beneath. Tibiæ III and IV without small dorsal spine. Vulva figured.

Antigua. Several females.

Sidusa stoneri sp. nov.

Plate II, figs. 3-5

♂ total length 4 mm. ♀ total length 4 mm.

♂ The cephalothorax is dark brown, almost blue black in the eye area, with scattered flat iridescent scales and with an elongate pale mark on each side of the posterior part. Clypeus uniformly dark. The quadrangle of eyes is a little wider in front than behind, is a fourth wider than long and occupies two-fifths of the cephalothorax. The abdomen has an anterioral medium dark stripe, posteriorly divided into herring bone markings. The upper sides darker having a distinct pale mark between the sides and the medium mark. Under side of the abdomen is black. Clypeus and mandibles entirely dark; sternum and coxæ pale. Legs I and II reddish brown with patella and tibia thinly fringed with short hairs on the anterior side. All tarsæ pale. Legs III and IV pale with dark stripes and spots. Palpus dark with patella covered with snow white hairs.

♀ Clypeus dark with central pale spot. Sternum, legs and venter pale; the latter with a few dark spots. The pale markings on the cephalothorax more extended and the lateral dark markings of the abdomen more distinct than in the male. Vulva figured.

Antigua. One male and one female and three immature females.

With our present knowledge it is not possible to place more definitely the following species:

Misumena ♂ Barbados.

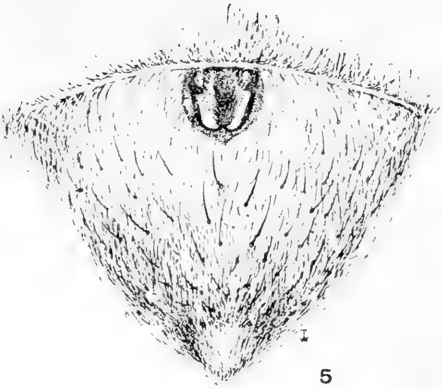
Olios immature Antigua.

Pardosa ♂ Antigua.

Dendryphantes ♀ Antigua.

PLATE I

6



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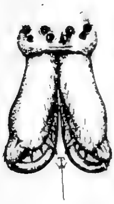

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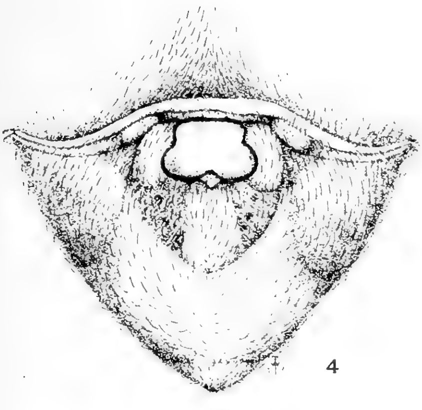

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PLATE I

Fig. 1. *Prionolæma gracilis,* eyes and mandibles of male

2. male palpus

3. abdomen of female

4. *Pseudosparianthus antiguensis,* vulva

5. *Sosippus insulanus,* vulva

6. *Oxyopeidon maculipes,* vulva

PLATE II

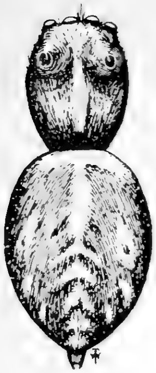
Fig. 1. *Cyrene gratiosa,* female

2. vulva

3. *Sidusa stoneri,* male

4. male palpus

5. vulva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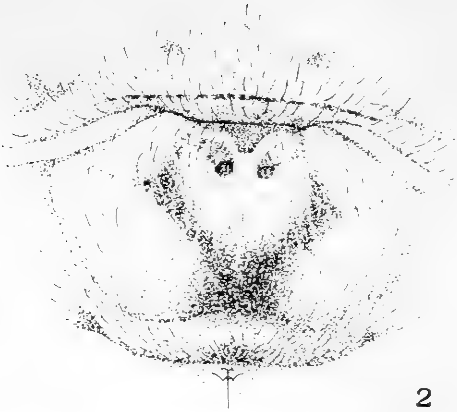
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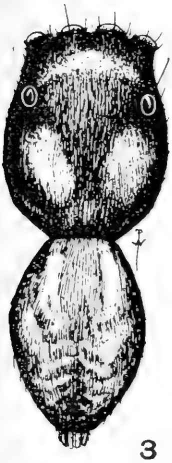
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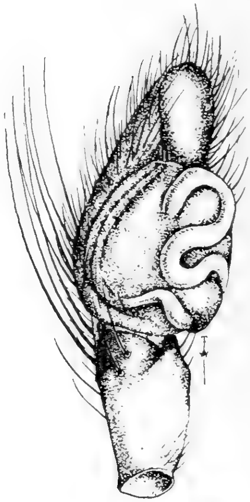
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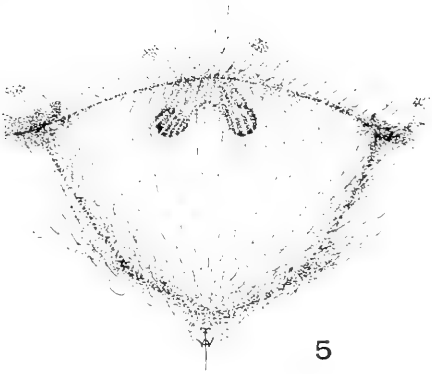
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REPORT ON CERTAIN FAMILIES OF HEMIPTERA-HETEROPTERA

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

H. G. Barber
Roselle, N. J.

Through the courtesy of Professor Dayton Stoner I have been privileged to study certain families of the Hemiptera-Heteroptera taken by the Iowa Expedition to Barbados and Antigua Islands in the West Indies during the summer of 1918. Only the following five families were sumbitted to me: *Coreidæ, Pyrrhocoridæ, Lygæidæ, Reduviidæ,* and *Tingidæ.*

The collection, though small in number of species represented, contains some long series which have been of great assistance in helping to trace the synonymy of several doubtful forms. Only one species, *Doldina antiguensis,* is new. None of the others are endemic to these particular islands but have a more or less wide distribution throughout most of the other islands of both the Lesser and Greater Antilles. In fact most of them are common continental species, the majority ranging from northern South America through Central America and Mexico to the southern United States.

Family **Coreidæ**

Phthia picta Drury

1770. *Phthia picta* Drury, Ill. Nat. Hist. 107, Pl. 45, Fig. 1.

Six specimens from Barbados. This is a widely distributed and common species in the neotropical realm where it is often injurious in gardens. Its extreme variability has given rise to a long synonymical list (McAtee Bull. Brklyn. Ent. Soc. XIV, 13, 1919.) Readily distinguished from the larger and more brightly colored *lunata* Fab., the only other species likely to be found in the West Indies, *P. picta* has been recorded from the following islands: Cuba, Guadeloupe, Antigua, Grenada, San Domingo, and Porto Rico. In the United States it occurs in Florida, Texas, and southern California.

Coreocoris fusca Thunberg

1783. *Corecoris fusca* Thunberg, Nov. Ins. Sp., II, 44.
1832. *Coreus confluentus* Say, Het. N. Harm. Ind., 11.
Sagotylus confluentus (Uhler, Distant, L. and S. Cat., not Say.)
1852. ? *Spartocera alternata* Dallas, List, II, 374.

Six adults and twenty-six nymphs from Antigua. A common species within its recorded range from Argentine Republic on the south to Mexico, West Indies, and the southern United States. Having such a wide range it is naturally subject to considerable color variation, as remarked by Stal. Lethierry in 1881, recorded *Spartocera alternata* Dallas, originally described from Brazil, as occurring in Guadeloupe and Martinique. As Dallas' description corresponds almost exactly to certain darker forms of *fusca* there is little doubt in my mind that the two refer to the same species. Although the species known as *confluenta* Say from the southern United States is paler and the males have the posterior margin of the genital segment a little more deeply sinuate, I can find no structural differences which will serve to separate this as a distinct species. Say's *diffusus* from North Carolina is quite distinct from *fusca* Thunb. *C. batatas* Fab. is also common throughout the West Indies, although none were secured by the Iowa Expedition. This latter species was named by Uhler as *fusca* from Grenada and St. Vincent according to Distant, who has seen the identical specimens.

C. fusca has been recorded from Cuba, St. Bartholomew, St. Vincent, Grenada, Guadeloupe, Martinique, and Porto Rico. I have also seen specimens from Jamaica and Dominica in the collections of the American Museum of Natural History.

Chariesterus gracilicornis Stal

1870. *Chariesterus gracilicornis* Stal, Enum. Hem., I, 178.

Twenty-three specimens from Antigua. Occurs throughout the West Indies, having been recorded from St. Eustatius, Cuba, Porto Rico, Jamaica, and Isle of Pines. I have seen specimens from Cuba, San Domingo, St. Croix, Guadeloupe, Jamaica, and Porto Rico (Coll. Am. Mus. Nat. Hist.).

This species differs from *antennator* Fab. in having the elongate basal segment of the antennæ unarmed and the third segment much less expanded; the lateral edge of the pronotum without spines. Uhler reports *C. antennator* from Cuba. Specimens of this latter species from Andros Is., Bahamas, are in the collection of the American Museum of Natural History.

Catorhintha guttula Fabricius

1794. *Catorhintha guttula* Fabricus, Ent. Syst., 162.

Thirty-four specimens from Antigua. Hitherto reported from Cuba, Jamaica and Grenada (Uhler as *selector* Stal). Mr. Harold Morrison took it in San Domingo and I found it common in Porto Rico. W. L. Distant reports that Uhler's *selector* from Grenada is *guttula* Fab. I have seen specimens of the former species taken by Mr. Morrison in San Domingo. *C. guttula* is distinguished from *selector* by having the head provided with a spine at the base of each antenna and the black tergum bi-maculate with yellow. *C. mendica* is larger, more maculate with fuscous, and has relatively shorter and blunter spines on the head.

Key to species of *Catorhintha*

1. Apex of antenniferous tubercles unarmed; tergum black immaculate. *selector* Stal
   Apex of antenniferous tubercles outwardly produced in a spine; tergum bimaculate with yellow. .... 2.
2. Size larger (10-12 mm.). Legs and ventral parts more maculate with fuscous. Apex of head more anteriorly prolonged. Spines of head less acute and relatively shorter .... *mendica* Stal
   Size smaller (8-9 mm.). Legs and ventral parts paler and less maculate with fuscous. Apex of head less drawn out and spines of the head more attenuated and acute .... *guttula* Fab.

Anasa scorbutica Fabricius

1775. *Anasa scorbutica* Fabricius, Syst. Ent., 706.

Two specimens from Antigua. Recorded from the following islands: Cuba, Jamaica, St. Vincent, Grenada, and Guadeloupe. Specimens from Porto Rico and San Domingo are in the collection of the American Museum of Natural History. Other species of *Anasa* known and recorded from the West Indies are *bellator* Fab., *andresii* Guer., *acutangula* Stal and possibly *tristis* DeGeer. *A. scorbutica* is readily differentiated from the other named species by having the head armed with a long slender spine above each antenna and having the hind femora armed with two stout teeth or spines.

Key to the species of *Anasa*.

1. Head behind antenna unarmed; head bivittate with black; hind femora unarmed .... *acutangula* Stal
   Head behind antenna armed with a more or less evident spine or tubercle .... 2.
2. Head dorsally yellowish with two wide black vittæ .... 3.
   Head dorsally destitute of two black vittæ .... 4.
3. Apex of tylus not extended beyond apex of antenniferous tubercles; longer and more slender apical segment of antenna more or less ochraceous; median longitudinal pale calloused line of pronotum conspicuous to near posterior margin; narrow species. .... *andresii* Guer.
   Apex of tylus well extended beyond apex of antenniferous tubercles; shorter and stouter apical segment of the antenna concolorous; tubercles at base of antenna sometimes obsolete; median longitudinal line of pronotum narrow, inconspicuous and obsolete behind middle; broader species. .... *tristis* DeGeer
4. Head behind antenna armed with a short tubercle or spine; hind femora beneath destitute of distinct spines .... *bellator* Fab.
   Head behind antenna armed with a long, sharp spine; hind femora beneath armed with one or two conspicuous spines toward apex. *scorbutica* Fab.

Leptocoris filiformis Fabricius

1775. *Leptocoris filiformis* Fabricius, Syst. Ent., 727.

Four specimens from Antigua. Recorded from the following islands: Cuba, Isle of Pines, Jamaica, Grenada, St. Vincent, and Porto Rico. The collection of the American Museum of Natural History contains material from Haiti, Cuba, and Porto Rico. A closely related species, *L. tipuloides* DeGeer, has been taken by Mr. Morrison in San Domingo. *L. filiformis* is smaller and more slender than *tipuloides* with the second and third segments of the antenna nearly equal; the veins at the apical margin of the corium fuscous, but the basal part of the membrane never infuscated; apex of the posterior femora very rarely reddish; the sinus of the male genital segment being much more deeply sinuate.

Megalotomus rufipes Westwood

1842. *Megalotomus rufipes* Westwood, Hope Cat., II, 19.
1842. ? *Alydus simplex* Westw., Hope Cat., II, 18.
1842. *Alydus consobrinus* Westw., Hope Cat., II, 20.
1860. *Alydus pallescens* Stal, Rio Jan. Hem., I, 34.
1871. *Alydus debilis* Walker, Cat. Het., IV, 160.
1901. *Megalotomus jamaicencis* Distant, Ann. Mag. Nat. Hist., VII, 427.

Fifty-one specimens from Antigua and nine from Barbados. This is a very common species throughout the West Indies. Recorded from the following islands: Cuba, Isle of Pines, Jamaica, Grenada, St. Vincent, and Guadeloupe. The collection of the American Museum of Natural History contains specimens from Cuba, San Domingo, Guadeloupe, Porto Rico, and Martinique. It is subject to great color variation, as pointed out by Van Duzee (Bull. Buffalo Soc. Nat. Sci., VIII, 12, 1907). There is no doubt in my mind that Distant has redescribed one of the many color forms as *M. jamaicensis* from Jamaica.

This species may be recognized from our *M. quinquespinosus* Say by having the humeral angles produced in an acute backwardly directed spine and the fourth antennal segment longer than the second and third segments taken together; the terminal segment not pale ringed at base.

Harmostes serratus Fabricius

1794. *Harmostes serratus* Fabricius, Ent. Syst. IV, 75.

Twenty-four specimens from Antigua. Known as a common species in the West Indies and already recorded from Jamaica, Cuba, San Domingo, Grenada, and St. Vincent. Specimens from Cuba, Jamaica, and Porto Rico are in the collection of the American Museum of Natural History.

The apex of the tylus is produced into a sharp spine, and the antenniferous tubercles are also outwardly armed with sharp spines; the lateral margins of the pronotum serrate; the apex of the rostrum reaches upon the base of the abdomen. Johnson and Fox (Ent. News, III, 59, 1892) report *nebulosus* Stal from

Jamaica. This may be a misidentification. Gibson (Ent. News, XXVIII, 444, 1917) is certainly in error in stating that the beak in *serratus* does not extend beyond the metasternum and in reporting the species as occurring over practically the entire United States. Van Duzee in his Catalogue records it from Florida and Texas.

Harmostes affinis Dallas

1852. *Harmostes affinis* Dallas, List Hem. II, 522.

Seven specimens from Antigua. These answer in every respect to Dallas' short description of the species, the habitat of which was unknown. Mr. Van Duzee in recording the species from Florida (Bull. Buffalo Soc. Nat. Sci., IX, 161, 1909) gives a good account of the differences between this species and *serratus*. It is known also from Jamaica.

Corizus hyalinus Fabricius

1794. *Corizus hyalinus* Fabricius, Ent. Syst. IV, 168.

Three specimens from Antigua. This species, almost cosmopolitan in its range, has been recorded from Cuba, Jamaica, and Grenada. I have determined specimens in the collection of the American Museum of Natural History from Cuba, San Domingo, Antigua, and Porto Rico. The West Indian specimens differ in no respect from those in the United States. Van Duzee in 1909 reported it from the Bermuda Islands.

Corizus sidæ Fabricius

1794. *Corizus sidæ* Fabricius, Ent. Syst. IV, 169.
1859. *Corizus pictipes* Stal, Freg. Eug. Resa, Ins., 239.
1842. *Corizus vincentii* Westwood, in Hope Cat. II, 26.

One hundred and four specimens from Antigua and three from Barbados. A widely distributed and common species throughout most of the neotropical realm, spreading into the southern United States. Reported from Grenada, St. Vincent, Jamaica, Cuba, and Isle of Pines. Specimens from San Domingo, Guadeloupe, Porto Rico, Cuba, and Jamaica are to be found in the American Museum of Natural History collections. Mr. Morrison has taken it also in St. Croix. This species is subject to great color variation. Owing to Distant's excellent figure of *C. vincentii* Westw. (Proc. Zool. Soc. Lond., Pl. XXX, Fig. 3, 1901) it is possible to pronounce it as one of the many color forms of *C. sidæ*. The artist has, however, made the first segment of the antenna a little too short.

Jadera hæmatoloma Herrich-Schäffer

1847. *Jadera hæmatoloma* Herrich-Schäffer, Wanz. Ins., VIII, 103, Fig. 873.

One brachypterous specimen from Antigua. It has been reported from Cuba and Jamaica. There is some doubt concerning the identity of this single, rather badly greased specimen, because of its red color. The head, antennæ, legs, and abbreviated membrane are black; elsewhere red, probably due to its immaturity.

Family **Pyrrhocoridæ**

Dysdercus discolor Walker

1872. *Dysdercus discolor* Walker, Cat. Het., V, 190.
1881. *Dysdercus delauneyi* Lethierry, Ann. Soc. Ent. Belg., XXV, 10.
1894. *Dysdercus annuliger* Uhler, Proc. Zool. Soc. Lond., V, 189.

Although this was not taken in either Antigua or Barbados the collection contains one specimen from Montserrat, two from St. Lucia and two from Grenada. Lethierry in 1881 described this as *D. delauneyi* from Guadeloupe. Uhler in 1894 redescribed it as *D. annuliger* from Grenada and also reports it from St. Vincent in 1894. Distant (Ann. Mag. Nat. Hist., 1902) states that Uhler's species is the same as Walker's. Ballou (West Indian Bulletin 1906) reports *delauneyi* (=*annuliger* Uhler) from Montserrat, Guadeloupe, Dominica, Martinique, St. Lucia, Barbados, St. Vincent, Grenada, and the Grenadines. I have seen specimens from Dominica in the collection of the American Museum of Natural History.

It is a dark red species subject to some color variation, but when fully colored has the vertex of the head, more or less of the posterior lobe of the pronotum, and the corium and legs fuscous; the antennæ are black except at base with a conspicuous pale ring at base of the fourth segment. Often the legs and antennæ are more or less red. All ventral parts of the body are red, with the incisures of abdomen piceous. Membrane fuscous narrowly pale-bordered. Other species of *Dysdercus* reported from the West Indies are *andreæ, caribbæus, fervens, jamaicensis, mimus, sanguinarius, fernaldi,* and *sutu-rellus.* Some of these are undoubtedly synonyms.

Dysdercus andreæ Linné

1758. *Dysdercus andreæ* Linné, Syst. Nat., ed. X, 448.

One hundred from Antigua with several nymphs; one from St. Kitts, one from Virgin Islands and one from Montserrat. This is a very common species in the West Indies referred to by Ballou in 1906 as the Leeward Islands Cotton Stainer. It has been found in southern Florida. Recorded from Cuba, Jamaica, St. Bartholomew, Antigua, Montserrat, San Domingo, St. John, St. Kitts, Nevis, and Guadeloupe. Specimens from Cuba, Porto Rico, San Domingo, Antigua, St. Croix, Jamaica, Dominica, and Virgin Islands are in the collection of the American Museum of Natural History.

D. andreæ is a small, very prettily marked species varying considerably in size and in the amount of black markings present. Specimens occur without the usual black fascia anteriorly and posteriorly on the pronotum and others as well without the typical black clavus and transverse fascia of the corium, or the latter much reduced in size. Occasionally the anterior and posterior margins of the pronotum are concolorous in place of white. The legs vary from red to all black.

Dysdercus howardi Ballou

1906. *Dysdercus howardi* Ballou, West Indian Bull., VII, 64-85.

Not in the collections made in Antigua and Barbados. However in the material sent to me by Mr. Stoner are two specimens of *D. howardi* from Trinidad, from whence they were described. These specimens were apparently labeled by Mr. Ballou from whom Mr. Stoner secured them. One of them bears a blank red label on the pin, indicating that it came from the type material.

D. howardi is very like *D. ruficollis* Linn., but distinct from that species by being narrower and with a longer head. It also resembles pale forms of *discolor* Walk. Whether it will stand distinct from the numerous other described forms from South America I am unable to decide at the present time. The head, basal segment of the antenna, anterior lobe and lateral margins of the pronotum, rostrum, and legs are reddish-ochraceous. The posterior lobe of pronotum, scutellum, and corium is ochraceous. The base of the fourth segment of the antenna and the collar of pronotum are white. The pleura are ochraceous-red with the anterior margin of propleuron and the posterior margins of all pleura and the acetabula broadly white. The venter is yellow with the incisures narrowly piceous. In the male the rostrum reaches to the apex of the second ventral segment of the abdomen. The membrane is fuscous, narrowly margined with pale yellow.

Family **Lygæidæ**

Ortholomus jamaicensis Dallas

1852. *Ortholomus jamaicensis* Dallas, List Hem. II, 555.
1894. *Nysius providus* Uhler, Proc. Zool. Soc. Lond. V, 182. (Specimens from the West Indies.)

Twenty-six specimens from Antigua and two from Barbados. Hitherto recorded from Jamaica, St. Vincent, Grenada, Porto Rico, San Domingo, and Cuba. I have studied material from Jamaica, Cuba, Porto Rico, San Domingo, and St. Thomas in the collection of the American Museum of Natural History. Although closely related to *O. longiceps* Stal, which I have treated as a synonym of *scolopax* Say, it can be differentiated from that species as follows: besides being smaller, its head is not drawn out quite so much anteriorly and the second and third antennal segments are a little longer with these parts, the legs and parts of the body less pilose.

Nysius ericæ Schilling

1829. *Nysius ericæ* Schilling, Beitr. Z. Ent., I, 86, Pl. 7, Fig. 10.
1852. *Nysius scutellatus* Dallas, List Hem., II, 553.

Three specimens from Antigua and two from Barbados. Described from Jamaica by Dallas as *Nysius scutellatus.* After very careful comparison of specimens from Porto Rico with Dallas' description and with specimens of *ericæ* from the eastern United States, I am forced to the conclusion that they are the same species. I can find no structural or color differences and feel no doubt in pronouncing them identical. I have seen this from Porto Rico, San Domingo, St. Thomas, and St. Croix. *Nysius basalis* Dallas from Jamaica is a much larger species.

Ischnorhynchus championi Distant

1882. *Ischnorhynchus championi* Distant, B. C. A., 193, Pl. XIX, Fig. 3.

One specimen of this little ochraceous species from Barbados. Described from Guatemala by Distant, it has been reported from Grenada, St. Vincent, and Jamaica in the West Indies. It is a very common species in Porto Rico, where I took it by sweeping low herbage.

Blissus leucopterus Say

1832. *Blissus leucopterus* Say, Heter. New Harm., 14.
1918. *Blissus leucopterus* var. *insularis* Barber, Bklyn. Ent. Soc., XIII, 38.

Seven specimens from Antigua. Probably occurs in most if not all of the Islands, as it has been recorded from Cuba, Jamaica, Grenada, and St. Vincent and I have seen specimens from Porto Rico, St. Croix, and San Domingo. Only one of the specimens in the collection is brachypterous. This variety, or race, occurs also in Florida.

Paromius longulus Dallas

1852. *Paromius longulus* Dallas, List Hem., II, 578.

Seventy from Antigua. Very common throughout the West Indies, ranging from northern South America to the southern United States. It has been recorded from Cuba, Isle of Pines, Porto Rico, and Jamaica. I have seen material from Jamaica, St. Croix, St. John, Antigua, San Domingo, Cuba, and Porto Rico as well as from the Bahamas.

Orthæa bilobata Say

1832. *Orthæa bilobata* Say, New Harm. Ind., 17.

Thirteen from Antigua and nine from Barbados. This species also has a wide distribution, from Argentine Republic in South

America through the intervening territory to the United States. Found throughout the West Indies and recorded from Cuba, Grenada, Jamaica, and St. Vincent. The American Museum of Natural History has material from Cuba, Dominica, San Domingo, Guadeloupe, Jamaica, St. Croix, and Porto Rico. Van Duzee also reported it from the Bermuda Is. in 1909.

O. bilobata is nearly twice the size of the next species, with a distinct transverse fuscous band across the corium.

Orthœa vincta Say

1832. *Orthœa vincta* Say, New Harm. Ind., 16.

Ten from Antigua and two from Barbados. According to my records this is distributed from Brazil, Ecuador, and Colombia through Central America, Mexico, and the West Indies to the southern United States. It is moreover not confined to the Nearctic and Neotropical realms, as it has been reported from Fiji, Tahiti, Hawaiian Is., Australia, Oriental, and Ethiopian countries. It is recorded from Cuba, Jamaica, St. Vincent, and San Domingo. I have examined specimens from Porto Rico, St. Croix, Dominica, and St. Thomas.

Family **Reduviidæ**

Zelus longipes Linné

1767. *Zelus longipes* Linné, Syst. Nat., ed. XII, 724.
1825. *Zelus rubidus* Lep. et Serville, Encyl., X, 724.
1835. *Zelus speciosus* Burmeister, Handb., II, 227.

Four adults and five nymphs from Antigua. This is the commonest and most conspicuous member of the genus from the Antilles. It has been recorded from Cuba, Isle of Pines, Jamaica, Haiti, St. Thomas, and Guadeloupe. The American Museum of Natural History possesses long series from Cuba, Jamaica, Dominica, Guadeloupe, St. Croix, San Domingo, and Porto Rico. In connection with the recording of this species in Mexico, Central America, and South America Champion (B. C. A., 252-253, 1899) gives a good account of the synonymy and varieties. This author suggests that *rubidus* is perhaps not really distinct from *longipes* from the Island of St. Thomas. After the examination of many West Indian specimens I am convinced that there is no good reason for keeping these separate. Occasionally the white bands on the legs and antenna are absent. I have not been able to distinguish Stal's species *mactans*, described from Cuba, from some of the varieties of *longipes*. It may prove to be but another variety.

Doldina antiguensis n. sp.

Testaceous, with the costal area of corium lightly embrowned, veins pale, attenuated apical angle bright red. Veins of the membrane lightly infuscated. Head, seen from above, with the post-ocular part gradually narrowed to the basal constriction, the two sides not at all parallel to each other; this region about twice the length of the pre-ocular part, long pilose laterally. The two post-antennal spines erect, acute, about as long as one-half the diameter of eye; ventral surface of head very sparsely pilose. Antennœ long, first segment reaching to apex of scutellum, very shortly and sparsely pilose. Pronotum one-fifth longer than wide, posteriorly armed with four rather long, erect, acute spines, those of the disk slightly longer than the humeral ones; the anterior lobe furnished with a somewhat elevated or calloused orbicular area on each side of a longitudinal, median shallow sulcus; transversely lightly impressed just behind the middle; lateral margins lightly embrowned; posterior lobe about one-third longer than the anterior lobe, closely punctate; provided anteriorly on either side of the middle with a short slightly elevated carina, evanescent before middle of the disk; between these provided with a distinct, rather deep, broad, median sulcus extended to line of discal spines; extending anteriorly just within the humeral spines on either side is another shallow sulcus fading out about the middle with a short slightly elevated carina, evanescent before middle of the disk; between this and the carina is a short, almost obsolete sulcus more evident anteriorly; the lateral margins provided with a faint carina. The posterior margin of the pronotum straight in the middle, produced on either side of the base of the scutellum into a short, scooped out, obtuse lobe. Clavus apically and inner area of the corium membranaceous, translucent; between the elevated pale veins opaque and somewhat roughly punctate, slightly embrowned. Membrane reaching only a trifle beyond apex of the abdomen. Beneath shining testaceous, pilose; first three abdominal segments armed at the posterior apical angles with conspicuous spines. Length, male, 17 mm., width 2½ mm.

Type, a single male from Antigua, July 15, 1918, collected by Professor Dayton Stoner. Owing to the kindness of Professor Stoner the type is deposited in the collection of the American Museum of Natural History.

This species is apparently closely related to *D. carinulatus* Stal, the female of which was described from Brazil. Stal's description is so meager that it is impossible without an examination of the type to determine with certainty the affinity of *antiguensis* with Stal's species. They agree in having the first three segments of the abdomen armed with spines, but the spines of the posterior lobe of the pronotum are not short nor are the median spines shorter than the lateral ones. Dr. E. Bergroth (Entomological News, XXIV, 263-264, 1913) described two new species of this genus from the United States. He mentions among other characters of his female *prætermissa* from Charlotte Harbor, Fla., that the posterior lobe of the pronotum is unarmed. Through the kindness of Mrs. Slosson I have a female of this same series and a male specimen from Everglade, Fla., collected by Mr. William T. Davis. Both of these specimens have a very small spinule or acute tubercle near the humeral angle. It is possible that the character of these spines is variable.

Family **Tingidæ**

Teleonemia sacchari Fabricius

1794. *Teleonemia sacchari* Fabricius, Ent. Syst., IV, 77.

Two specimens from Antigua. This has been reported from Cuba, St. Bartholomew, St. Vincent, Grenada, and Jamaica in the West Indies. It is fairly common in Porto Rico and has been found in Florida.

REPORT ON THE AQUATIC HEMIPTERA

Collected by the Barbados-Antigua Expedition
from the University of Iowa in 1918

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There is before me a very interesting small collection of water-bugs, the fruit of the University of Iowa expedition in 1918. This little lot, as always in aquatic Hemiptera from little-known places, is extremely puzzling, because, while all the forms are well-marked, there is no certainty but what there is one, or more, undescribed species present. This can be decided positively only by a monographic study of genera, for which material in the aquatic forms is, alas, but too scanty. In this collection there are long series of two forms only—*Arctocorisa antiguensis* n. sp., and *Gerris (Limnogonus) guerini L. & S. (marginatus Guér.)*. There are also several each of *Buenoa albida* Fieb. and *Pelocoris femoratus* P. B. The others are only in ones and twos and appropriate comment (or protest) is made where it seems called for.

The order of the families here set forth is that of "*A Catalogue of the Aquatic and Semiaquatic Hemiptera*" by Kirkaldy and Bueno, in Proceedings of the Entomological Society of Washington, XI, pp. 173-215. It is unnecessary to repeat here in detail the arguments for this arrangement and establish why the order in Van Duzee's *Catalogue* has not been followed for these families. Protracted study over a long period of years, adequacy of material, and acquaintance with the immature stages and familiarity with life-histories have led me to this arrangement as the more philosophical and that which represents most nearly, according to the present state of our knowledge, the phylogenetic affinities of these families. The true waterbugs form an unbroken series starting with the *Acan-*

thiidæ (Saldidæ), and going through *Ochteridæ, Gelastocoridæ, Naucoridæ*, and *Belostomatidæ* to the *Corixidæ*, the most specialized, and possibly, the most aberrant of these groups in the series. The *Notonectidæ* do not seem to fit in this linear arrangement and may temporarily be regarded as in the nature of an off-shoot. The *Gerridæ* and *Mesoveliidæ* are respectively connected with the *Reduviidæ* and the *Nabidæ*, and may be placed in that linear order, although not related to each other.

Family **Corixidæ**

Arctocorisa antiguensis n. sp.

Description—Head: Tumid, with a blunt median longitudinal carina in the male; eyes 4/5 as wide as the vertex; face flat in female, foveate in male.

Pronotum: Rastrate, more or less oval, anterior margin straight; with 8 or 9 black lines crossing it, sometimes interrupted; proportion of length to width, 3 to 7.

Tegmina: Clothed with long, fine prostrate hairs; clavus rastrate, also apical part of corium. Membrane without veins, of homogeneous texture, with short, fine light hairs; black vermiculate markings, varying in intensity with the age of the specimen, lighter toward the apex of the clavus, in which they become a few transverse irregular lines. The vermiculate markings coalesce to form longitudinal stripes, more or less pronounced.

Palæ: In the female, triangular in section and fossate on the face, the upper edge and each edge of face closely set with long setæ; length to width as 10 to 3; middle legs slender, femur nearly equal in length to the total length of the tibia, tarsus, and tarsal claw; tarsal claws long, slender, slightly longer than tarsus; the length of the tarsus together with its claws nearly one and one-half times as long as the tibia. Hind legs stout; coxæ elongate, stout, somewhat flattened; femora short, stout, apically ampliated, set with short stout spines on the outer edge and fringing natatorial hairs on the inner; tibiæ flattened, paddle-shaped, a row of moderately long spines on the outer edge, and heavily fringed with swimming hairs on the inner; proportional lengths of coxa to femur to tibia to tarsus as 18 to 18 to 23 to 9.

In the male, *palæ* spatulate and curved, usual fringing hairs on lower edge, a long row of stout legs on the curved side, a short row on the straighter; middle legs slender and cylindrical, coxæ small; femur to tibia to tarsus to claws as 30 to 16 to 10 to 14; claws simple, slender. Hind legs as in female. Asymmetry to right.

Females: length, 8.3 mm. to 8.5 mm.; width 3.4 mm. to 3.8 mm.

Males: length, 7 mm. to 8 mm.; width 3 mm. to 3.2 mm.

These measurements are not quite exact, as the specimens are somewhat distorted.

Type: male, Antigua, July 28, 1918, L. Stoner.

Allotype: female, Antigua, July 28, 1918, D. Stoner.

Paratypes: males, 18 specimens, Antigua, July 28, 1918, D. and L. Stoner; 1 Barbados, May 16. Females, 19, Antigua, same date.

Type and holotype in collection of the State University of Iowa; paratypes in same and in collection of J. R. de la Torre-Bueno.

The preceding description is frankly conventional and leaves much to be desired. Many structures are omitted or referred to very superficially, but enough has been given to fix the species. The ordinary descriptions of the palæ do not seem to me to convey a definite picture; they are far too generalized and too subtle characters to be put into words without making microscopic mounts both for description and for identification. It is to be hoped that when Dr. Hungerford completes his studies, the group will be on a firm foundation of pure structure, a condition which at present does not exist. To be sure, pattern in this group gives a certain individual aspect to each species, but unless we know the group as a whole a description of the color pattern is vague and conveys no mental image. There are other structures, quite visible, the sternites, for example, which should yield excellent comparative characters, but which do not appear to have been thus far employed in this family.

In addition to the 73 adults from which the type series was taken, there are six nymphs in various instars.

Family **Belostomatidæ**

Belostoma impavidum n. sp.

Description—Head: Tylus, long, two-thirds as long from eyes to tip as from anterior margin of eyes to anterior margin of thorax; the usual elliptical suture anteriorly; a few scattered short hairs are visible at a magnification of 74. Eyes one and one-half times as broad as long, overlapping prothorax at anterior angles. Antennæ concealed, as usual. Rostrum free, reaching distal end of anterior coxæ, thin, curved, length 7 mm; three visible segments; formula: I, concealed; II, 3; III, 2.5; IV, 1.2; segment III with long, narrow palps, .3 mm. long. Width of head, 7 mm., length, 5 mm.

Prothorax: Usual shape; anterior width, 5.8 mm., posterior, 10 mm.; median length 5.4 mm.; thoracic groove, 4 mm. from anterior margin;

the usual foveæ on each side of the median line, anteriorly. Anterior angles concealed under fringing hairs of eyes. Prosternum with a thin rounded median keel between the anterior coxæ. Anterior legs: tibia and tarsus together equal in length to femur; tarsal joints equal, tarsal claw a little more than half as long as a tarsal joint; femora 3 mm. wide at the widest part, quite stout, 7.5 mm. long.; face of femur with heavy pile in tufts; tibia simple.

Metathorax: Not visible, except scutellum, which is shorter than broad (5 to 6.5 mm.), length measured from prothoracic groove or indentation to apex, and breadth at groove; rugose, as usual.

Hemielytra: Junction equal in length to length of scutellum; clavus punctate, corium reticulately veined, margin punctate becoming obsolete apically; reticulation rises from the vein parallel to the claval suture, which sweeps around parallel to the margin of the membrane; veins of membrane practically parallel, forming 13 narrow longitudinal cells, the first two and the last two shorter than the others, the rest of nearly equal length, all being cut off by a marginal vein which is a continuation of the claval suture.

Middle legs: Claws .5 mm. long; third tarsal joint, .75 mm., second, .6 mm.; first, short, triangular. Tibia flattened, shorter than femur, which latter is grooved, with coarse pile on the edges of the groove to correspond with the pile on the tibia; mostly concealed in the groove of the joint; coxæ large, rounded trapezoidal, trochanters large, one side rounded, side applied to femora flattened.

Hind legs: Longest, tibia and femur of equal length; tibia flattened, angular, broad distally, with the usual long swimming hairs; exterior edge flattened, with a row of spines or stiff bristles on each angle; femur rounded, stouter than the tibia, with a shallow groove for the reception of the latter. Tarsi lost in type.

Mesosternum: Short medially and converted into two large prominent coxal acetabulæ, produced laterally till they meet the second abdominal segment, and beyond. *Metasternum* narrow, set in fork of mesosternum and with large acetabulæ.

Abdominal segments: Visible, 5, the first concealed, the second showing triangularly in the angle between the meso- and metasternum, disappearing in the posterior coxæ; third, fourth, and fifth segments equally wide at connexivum, third and fourth narrowed at the keel, the former slightly narrower than the latter, fifth of equal width throughout, a little narrower than the sixth, which also is of equal width throughout; seventh two-thirds wider than the sixth, and covered at the middle by the genital plate, split into two lobes at the extremity; genital plate as long as wide, rounded at the distal end. The usual narrow paired strap-like, hairy respiratory appendages.

Color: The usual olivaceous-brown of the family, lighter and darker in irregular patches (This may not be so in other specimens and no reliance is to be placed on it for differentiation; it is given only to complete the picture.)

Dimensions: Total length without appendages, 29.9 mm.
Greatest width, 14 mm.
Head: Long, 3.5 mm., wide, 6 mm., including eyes.
Prothorax: Long, 5.4 mm.; wide, at apex 5.8 mm., at base, 10 mm.
Scutellum: Long, 5 mm.; wide, 6.5 mm.
Abdomen, frcm apex of scutellum: Long, 16 mm.; wide, at widest part, 14 mm.

Note that the lengths are given with the parts of the bug in natural position; that is, head up, prothorax set back till its posterior edge is on groove in scutellum. The total length is derived by adding together the lengths of the head, thorax, scutellum, and abdomen from apex of scutellum. Much confusion in water bugs has arisen from neglect of this precaution. In the killing bottle many insects curl somewhat, or exsert parts habitually concealed; thus making a long collum or vertex; or lengthening or shortening some body segment.

Type: 1 male Antigua, June 28, 1918, Stoner, in collection of the University of Iowa. There are also 4 nymphs, one about the second stage, and the others about the fourth or fifth.

This species somewhat resembles *Belostoma fuscipes* Latr., but does not seem to belong to any of the species described of late years by Montandon. It is therefore described as new.

Family **Naucoridæ**

Pelocoris femoratus Pal. Beauv.

So far as descriptions and published distribution go, this is our common North American form. It is accordingly given as such. It has heretofore been recorded from Guadeloupe and other West Indian Islands. There are nine adults and eighteen nymphs in all stages from Antigua, June 28 and July 28, 1918.

Family **Notonectidæ**

Notonecta indica Linné

Two adults, one melanic, (June 28), and the other with the usual black membrane, (July 6), and also 3 nymphs, all from Antigua, are in the lot. The species has been recorded from Cuba only in the Antilles.

Buenoa antigone Kirk.

This seems to be the above species. At least, there is no other description fitting it so closely as the one named here. One specimen from Antigua, July 28, 1918. Heretofore recorded from Cuba, Jamaica, and Santo Domingo.

Buenoa albida Champion

Here is another form of doubtful authenticity! Ten specimens from Antigua, July 28; and three from Barbados, May 16. This species seems to be known only from Mexico.

Family **Gerridæ**

Gerris (Limnogonus) guerini L. & S. (*marginatus* Guérin)

There are forty adults and three nymphs from Barbados, May 21, and eight adults from Antigua, July 28, 1918. Two of the adult males are winged and twenty-four are apterous; five of the females are winged and eighteen are apterous.

This is a common West Indian species, heretofore recorded from Cuba, St. Vincent, Grenada, and Jamaica.

The three continental American forms from the Atlantic and Gulf sides of North America (of which this species is one) may thus be separated:

1 Antennal segment I longer than IV; small forms (less than 8 mm. long) 2
  Antennal segment I subequal to IV; larger forms (over 8 mm. long); antennal formula, I and IV : II : III.......*hyalinus* Fabr.
2 Antennal segment I nearly twice as long as IV, which is subequal to II and III, II shortest; abdominal segments pilose dorsally as well as ventrally in apterous; antennal formula, I : III and IV: II; 4½ to 6 mm. long..........*hesione* Kirkaldy.
3 Antennal segment I but little longer than IV, which is longer than III and subequal to II; III shortest; abdominal segments glabrous dorsally in apterous, comparatively slender form; antennal formula* I : IV : II : III; 7 to 7 ⅓ mm. long. *guerini* L. & S.

Rheumatobates sp. (*tenuipes* Meinert?)

One specimen taken at Barbados on May 21. This cannot be identified specifically on account of the absence of legs and antennæ.

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* (By antennal formula is meant the order of the comparative lengths of the antennal segments).

Family **Mesoveliidæ**

Microvelia (?) *pulchella* Westw.

One apterous specimen, Barbados, May 21, 1918, Stoner. This is the Westwoodian species type of the genus, so far as it is possible to determine from a single apterous specimen. Here is another group in which color has been much used as a specific character. In *Microvelia,* my esteemed contemporaries to the contrary notwithstanding, the only characters for distinguishing surely the winged and wingless forms are the head and its appendages, the legs, and the genitalia. The genus is certainly dimorphic; perhaps even polymorphic. It is a truism of taxonomy that the presence or absence of wings modifies profoundly the structure of the thorax, that portion of the body which contains and serves as anchorage to the alar muscles. Wing conditions *per se,* and therefore thoracic size and structure, cannot be used as specific characters to fix a species in all its forms. We must of necessity lay stress on the unchanging structures named above. For this reason, no specific description of any waterstrider for one form only may be considered adequate; and no description which does not lay stress on the unvarying structure is complete. The description may be excellent for one or another form, but useless for the undescribed one in the absence of the required universal characters.

Family **Mesoveliidæ**

Mesovelia sp.

One specimen, Antigua, June 28, 1918. Stoner. This specimen is in fair condition only. It is neither our Eastern United States *bisignata* Uhler, nor the smaller Antillean *M. amœna* Uhler. It *may* be *mulsanti* B. White, but this is a mere guess. Notwithstanding Horváth's 1915 monograph, the group continues in unsatisfactory condition. As may be noted, I still employ Uhler's name *bisignata* for our Eastern species, in the face of Champion's dictum in Biologia Centrali Americana. The species of *Mesovelia* are readily separable, but here again my preceding remarks apply. Horváth, to be sure, has drawn attention to two processes on the male genital plate, yet these alone are insufficient, for I have been able to separate by good characters Kirkaldy's *M. orientalis* from Horváth's *vittigera,* even though Horváth has synonymized them. Furthermore, all records of *M. mulsanti,* except the original one, are to be suspected and to be discarded, at least for the time being.

Here is the writer's *obiter dictum* on aquatic Hemiptera in general. It is far from wise, of course, for a writer to lay stress on any one idea, for it is likely to give rise to notions as to the poise of the stresser. But I here and now say that my insistence on structure rather than color for descriptive purposes rests on the difficulty of unravelling the snarl of such groups as the genus *Buenoa,* for instance. Take, for example, the four new species described in Biologia Centrali Americana. They are described by color, except for three or four *variable* structural characters, like impressions in the pronotum, common to several species; or distance between the eyes, a secondary sexual character; or length, which is variable within the species, and which may refer to more than one species, anyhow. I have before me hundreds of *Buenoa* and *Anisops* as I write. All have the same sordid white or yellowish glassy, transparent, more or less iridescent wing-covers—pearly, as they are so justly called. All have more or less—and variable—black and yellow markings in the thorax and scutellum. Of course, they differ structurally, but such things are not mentioned in the specific description. So when we have three or four forms of about the same size (within the specific limits), although we can indeed separate them structurally, which of the four, is, say, *albidus,* according to the description? One considers the distribution and hazards a guess. It is probably right on distribution and general considerations, but it is scarcely scientific. All one can do is to hope for the best. It is possible to declare it a new species, but there is always the uncertainty as to its real status; and why add to synonymy, already overloaded? No identification of aquatic Hemiptera may at present be accepted without question, except in those forms which have been worked over of late years monographically for limited groups, and in which authors have come to clean-cut conclusions. As to others, like this family and many others of the water-bugs, we have many descriptions, but no comprehensive work, and no work based on structure pure and simple. The species in these families in the Eastern United States have been controlled and are now distinguishable with certainty. But where is the material in abundance to work up other faunas? A certain amount is available on this side of the water, but the inaccessibility of the European collections makes difficult hard-and-fast tenable determinations. Collections of aquatic Hemiptera here and abroad are entirely inadequate. These insects are not the favorites of collectors; they are picked up in the most casual manner here and there; and later inadequately characterized by perfectly competent entomologists with an entirely superficial knowledge of the aquatic groups of Hemiptera as a whole —a knowledge very necessary to a proper discrimination and appreciation of characters, as well as to adequate descriptions based on fixed structures.

But nothing will ever be done permanently on any of the groups of aquatic Hemiptera until they are put on a thoroughgoing basis of pure structure. Anything other than this is trifling and negligible.

PLATE I

1

2

Fig. 1. *Belostoma impavidum* new species (dorsal view)
2. *Belostoma impavidum* new species (ventral view)

REPORT ON SOME POLYCHAETOUS ANNELIDS

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

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INTRODUCTION

The annelids discussed in this report were collected at two of the British West Indies, Barbados and Antigua, which lie in the North Torrid Zone. Barbados, which is the most seaward of the group, is located at 13° 4′ north latitude and 59° 37′ west longitude. It has a heavy rainfall, but no streams. The island is rising, and consequently it has a very regular coast-line. Antigua is located at 17° 6′ north latitude and 61° 45′ west longitude. It has scant rainfall because it is located in the belt of calms. Since the island is sinking, the coast line has deep indentations; this gives rise to very different habitats. The normal rise and fall of the tide at each island is from two to four feet. Along the shores at low tide specimens were found in the sand, under rocks, in the little tide-pools, on the reefs and flats, in old coral-stone, and along the shallow sea-bottom. Deep-sea dredging was done at Barbados at a depth of 130-140 fathoms. In all, three chief methods were used in obtaining this material: tide-collecting, dredging, and diving.

CLASSIFICATION

Phylum *Annulata*—Bilaterally symmetrical animals with an extensive cœlome, distinct segmentation, and unjointed appendages.

Class *Chætopoda*—Segments bearing lateral groups of setæ.

Sub-class *Polychæta*—Setæ borne on parapodia.

Order *Errantia*—Carnivorous free Polychæta with protrusible pharynx bearing jaws. Branchiæ generally on dorsal parapodia.

Family *Amphinomidæ*—Body vermiform or oval and flattened. Head bearing a peculiar sense organ, the "caruncle."

1. *Hermodice carunculata.*
2. *Eurythæ pacifica.*

Order *Sedentaria*—Vegetable feeding Polychæta which permanently inhabit tubes. No protrusible pharynx; no jaws or teeth. Branchiæ, when present, usually confined to anterior end and sometimes represented by modified tentacles.

Family *Serpulidæ*—Tubes calcareous.

1. *Spirobranchus giganteus.*
2. *Pomatostegus stellatus.*

Family *Sabellidæ*—Flexible tubes constructed of mud and sand.

1. *Sabella melanostigma.*
2. *Dasychone conspersa.*
3. *Parasabella sulfurea.*
4. *Bispira (Sabella) melania.*

DISCUSSION OF ANNELIDS

The phylum Annulata contains the highest type of worms. They are found in abundance everywhere, some species growing to the length of a foot or two. Some are carnivorous, others vegetarian, while many are mud-eaters that swallow mud and sand to obtain the organisms contained therein. They comprise the segmented worms, which number about 4,000 species divided into four classes: the *Archiannelida, Chætopoda, Hirudinea,* and *Myzostomida.*

All annulates are bilaterally symmetrical, with head distinct, body elongated, digestive tube present, cœlome extensive, appendages paired and unjointed. Segmentation is the most characteristic feature of the annelids, each segment containing a separate and similar set of internal organs. In most annelids the head is more or less distinctly marked, containing mouth, brain, and sometimes bearing tentacles, cirri, palpi, and eyes. Lateral appendages in the annelids are muscular projections of the body wall, called parapodia.

In all annelids except the very lowest a well-developed system of blood-tubes, often carrying red blood, is found. The most important of these are: a dorsal longitudinal tube just above the intestine, a ventral tube just beneath it, and transverse tubes connecting the two. The excretory system consists of a pair of coiled tubes in each somite, which are called nephridia. Each one of these opens into the body cavity at one end and carries liquid waste through a nephridial pore to the outside. The nervous system consists, in most cases, of a cerebral ganglion, œsophageal connectives, and a double ventral nerve-cord, segmented into a series of ganglia. In the unisexual annelids the reproductive organs are not well marked except during the breeding season. In the hermaphroditic forms, which have a direct development, there is a complicated system of reproductive organs.

All annelids live in water or in moist places on the land or in the earth, the majority being marine. They swim mostly at night, and serve as food for fish and other animals.

The class Chætopoda, or "bristle-worms," comprises the Earthworms, Fresh-Water Worms, and Marine Annelids. This class has bunches of bristles, or setæ, on both sides of each segment of the body, which serve as organs of locomotion. The setæ are of various shapes and colors. They are usually chitinous and vary with the genera. This class contains two subclasses: (1) the *Polychæta,* and (2) the *Oligochæta.*

The subclass *Polychæta,* to which the annelids described in this paper belong, are the "many-bristled" worms. They are mostly marine, divided into two orders: (1) the Errantia, or free-swimming; (2) Sedentaria, or sedentary worms. Many Polychæta are beautifully colored—some in vivid reds, greens, blues, and yellows; others in the more sober shades of browns and grays. Some are iridescent; some are phosphorescent.

The majority of the Polychæta have a cylindrical and very mobile body and have a considerable number of segments, definite in number in some groups and varying in others. The segments composing the trunk may be all alike or may constitute two more or less sharply marked regions, the thorax and the abdomen, which differ in the character or in the arrangement of the chætæ. The body-wall consists of a cuticle, an epidermis, muscular layers, and a layer of peritoneum. The cuticle is perforated in many places by the ducts of the unicellular glands of the epidermis, which consists of a single row of cells. In the tubicolous forms these glands secrete the material used in the construction of the tube. In addition, the epidermis frequently contains sensory cells, which are in many cases contained in sensory papillæ. The muscular part of the body wall consists of two layers. The outer layer has the fibres disposed circularly, while the inner one has them arranged longitudinally. The peritoneum is a single layer of cells.

Among the Polychæta, one branch has a head consisting of a prostomium and a peristomium. The former is a lobe overhanging the mouth and frequently bears paired eyes, tentacles, and palpi. The latter is the first complete ring and usually bears cirri. The second branch of Polychæta has a peristomium which is frequently notched. It completely hides the prostomium, which becomes an insignificant organ. The tentacles are reduced, but the palpi become greatly developed. In neither branch do the prostomium and peristomium bear parapodia.

The external segmentation affects the internal structure by dividing the cœlome into somites by means of septa. In burrowing and tubicolous forms the septa are frequently incompletely developed, or even absent; and when the body is less distinctly segmented externally, it varies greatly in diameter during movement. The alimentary system presents certain modifications of a systematic value. It consists of mouth, buccal cavity, pharynx, œsophagus, digestive glands, stomach, intestine, rectum, and anus. In the Nereidiformia the pharynx is protrusible in part, forming a proboscis which is worked by the pharyngeal muscles. Those worms having a proboscis also possess jaws and numerous denticles.

The circulatory or vascular system is well developed. This consists of a dorsal and of a non-contractile ventral vessel, extending along the whole length of the body and giving off paired segmentally-arranged vessels, which pass to the intestinal wall and to the body wall. This system of vessels in the majority of cases contains a respiratory fluid colored red by hæmoglobin in solution. The blood flows anteriorly in the dorsal vessel and posteriorly in the ventral vessel.

The nervous system consists of a dorsal cerebral ganglion, or "brain," connected by circum-œsophageal commissures with the anterior end of a ventral chain of ganglia. The circum-œsophageal commissures spring from the outer corner of the brain, and from each arises a nerve which leads to the head sense organs. The first ventral ganglion lies in the third segment and represents at least two ganglion-pairs fused together.

Special respiratory organs are present in the Polychæta in the form of projections of the parapodia or the appendages of the head.

With a few exceptions the Polychæta are unisexual. The sexual cells are developed in all cases from the lining epithelium of the body-cavity. The exact spot where this occurs varies in different cases. The eggs and spermatozoa in the Polychæta are discharged into the sea either by rupture of the body wall or through the nephridial pore. The male and female elements unite, after which the fertilized eggs undergo development in one of three ways: (1) free-floating; (2) embedded in jelly; or (3) attached to the body or to the tube of the worm. The larval forms differ greatly from the adults. The free-swimming larva is known as a "Trochosphere." In different species, however, the larva present various departures from this type. The little animal is equipped for an independent life by means of provisional chætæ which help to keep it balanced. It is quite at the mercy of the sea, which disseminates the species by carrying it hither and thither. The larvæ of certain species occur at definite periods in great numbers at the surface of the sea, where they serve as food for other animals.

A peculiar worm, *Palolo viridis,* is used as food for man. This worm spawns on two days in October and on two in November—the day on which the moon is in her last quarter, and the day before. At these times they leave the reefs and come to shore. The natives of Samoa and Fiji eat these alive or baked, tied up in leaves. They consider these so great a delicacy that the chiefs who live on the shore send them as gifts to those living inland.

A few Polychæta are pelagic, while the majority live on the sea-bottom. They occur in the greatest abundance near the shore; but they are also found at all depths in the ocean, where the tube-dwelling forms are more abundant than the free forms. A considerable number are commensals, habitually associating with other animals for the sake of food and shelter. Tubes and horny jaws of various Polychæta have been detected in the strata from the Cambrian period onwards.

The geographical distribution of these worms is wide-spread. Many genera are cosmopolitan, although only a few species are common to all the great oceans.

Order *Errantia:* Carnivorous, free Polychæta with protrusible pharnyx, bearing jaws. Branchiæ generally on dorsal parapodia.

Family *Amphinomidæ:* The body in this family is either vermiform, as in the genus *Eurythœ,* or flattened, as in the genus *Hermodice.* The head bears a peculiar sense organ, called the dorsal ridge or "caruncle," which is a leaf-like process overlapping three or more segments. The parapodia bear gills.

Hermodice caruncculata Kingberg

Plate V, Figs. 2 and 3; Plate VI, Figs. 3, 4, 5, and 6

The largest speciment found is 230 mm. long and 20 mm. wide at its maximum breadth. It decreases posteriorly to about 5 mm. at the anal segment. The body is a compressed quadrangular shape in cross-section, flat ventrally and slightly arched dorsally. On the dorsal side the color is pale olive-green, shading to gray laterally; while on the ventral side the color is a tan-gray, with a distinct bluish-black median stripe along the ventral groove. This stripe is not so evident in the young forms. The caruncle, located dorsally, is oval and extends posteriorly to the fifth segment. It consists of two rows of somewhat converging laminæ, eight in number. From the anterior end projects the median unpaired palp, at each side of which are located two black eye-spots. The other four palpi are shorter. The first pair are located in front of the anterior pair of eyes and are at the anterior edge of the mouth elevation. The more posterior pair are farther apart and are located at the sides of the second pair of eyes. The mouth is oval. The posterior circumference of the mouth opening is on the edge of the fourth segment of the ventral surface. The median parts of the fifth and sixth segments enter into the formation of a lip. There are two rows of parapodia, dorsal and ventral, separated from each other by a wide side-wall of the body. The ventral row is arranged in a straight line. The dorsal parapodia, on the other hand, are alternately drawn nearer the ventral ones. This outstanding peculiar characteristic makes them appear as a double row. Each of the ventral parapodia bears a wide fan-shaped bundle of setæ with a small cirrus. There are two kinds of setæ: the one rather wide and finely toothed along the concave edge; the other with a sharp spur-like projection. The dorsal parapodia are larger. Each one bears a flat bundle of setæ, a long slender cirrus, and a branchia. The bristles are simple, long, thin, and hair-shaped. The cirrus has a broad base and extends from the posterior edge. The branchiæ spring from one main trunk and are branched dichotomously several times. The filaments are fringe-like. The specimen described above was found near the "Pillars of Hercules," Antigua.

The Hermodice is a very predacious animal. It is found under stones at low-tide, and it is difficult to capture because of the nettle-like sting of the setæ. The writer's own experience in securing the above described specimen illustrates emphatically the paralyzing effect of the sting of these setæ. As the writer was lifting a stone, she suddenly discovered this monstrous worm endeavoring madly to get away and hide under surrounding rocks. Being unfamiliar with the habits of this animal as well as unwarned of the disastrous results of touching it, she seized it with bare hands in order to prevent the escape of so splendid a specimen. Immediately her fingers and palms were covered with slender, sharp, glassy setæ, which worked their way under the skin and into the flesh. For about a week following, the fingers were numb and apparently deprived of the sense of touch.

Localities: Jamaica, Florida Cape, Hayti, Antigua, and Dry Tortugas.

Eurythœ pacifica Kingberg

Plate VI, Figs. 1 and 2

A description of this species was not found in any literature available, except in the narrative and preliminary report of the Barbados-Antigua Expedition by Prof. C. C. Nutting. The body of the present specimen is 160 mm. long. It is about twice as broad as it is thick, measuring 10 mm. at its greatest width. It is quite flat on the dorsal side. There are 120 segments. The color of the body is bright red, while that of the parapodia is an orange-red. This vivid color is probably an evidence of warning, because these animals, which the natives call "sea scorpions," are very pugnacious. The caruncle is a simple, smooth, longitudinal swelling, the most posterior edge of which is on the third segment. In front of the caruncle are four black eye-spots. The anterior pair are the larger. There are five short Indian-club shaped palpi. The unpaired one is the shortest and scarcely as high as the caruncle. The mouth is oval and extends back as far as the third segment. The median parts of the fourth and fifth segments enter into the formation of a lip. The parapodia appear to be in two rows, dorsal and ventral. These may be the notopodia and neuropodia. Although they meet at the first segment, from the second segment to the posterior region they are widely separated; from here they gradually converge to the end. Each of the ventral parapodia bears a small bundle of setæ with a stout cirrus. The setæ are very thick and stiff, and extend straight out. They terminate in two points of unequal length, the longer and wider of which has the greater curvature. The cirri are on the posterior border of the parapodia. They originate from a thick base and extend to a blunt point. The dorsal parapodia are short and thick. They bear large bundles of setæ, a cirrus like that of the ventral parapodia, and the branchiæ. The setæ of the dorsal parapodia, which extend outward and upward, are of two kinds: the one fine, glistening bristle-like setæ, simple and linear in shape; the other kind serrated with toothed edges pointed backward. The branchia is a low, brush-shaped structure. It is located back of the dorsal cirrus and extends toward the flat dorsal surface. There are about eight short stems arising from a main trunk. These subdivide into small branches, and they end in thick, wedge-shaped filaments.

The anus is dorsal and is located on the third from the last segment. The last segment bears two small knobby cirri. This specimen was found in a conch-shell at Barbados.

Localities: Mau Wau, Formosa; Batan Island; Tataan, Tawi Tawi, San Pascual, Burias Island; Barbados.

Order *Sedentaria*—Vegetable feeding Polychæta which permanently inhabit tubes. No protrusible pharynx; no jaws or teeth. Branchiæ, when present, usually confined to anterior end and sometimes represented by modified tentacles.

Family *Serpulidæ*—Tubes calcareous.

Spirobranchus giganteus Pallas

Plate VI, Figs. 6, 7, and 8

This is a relatively large specimen 75 mm. long, including the branchiæ, 9 mm. wide in the thoracic region, and tapering posteriorly. The body, which is divided into thorax and abdomen, is oval in cross-section. On each side of the thorax, which is divided into 6 segments, there are 6 bundles of setæ, located just above the thoracic membrane. The setæ on the collar are of two kinds, which differ only in length and in degree of curvature. The longer ones are slightly bent; the shorter ones are strongly curved. The thorax is also provided with an undulated membrane on each side, employed chiefly in smoothing the inside of the tube. This is a modification of the cirri. The shield glands are confined to this region. The branchiæ, which are 15 mm. in length, are in two bundles, each having 5 whorls. The branchial filaments are numerous and are situated on a broad base. The peduncle is large, wide, but thin. Its edges are almost cutaneous and protrude like wings so that the branchiæ can be withdrawn into them. The operculum is plate-shaped, and out of its depression arise two large antler-like processes and two smaller horn-like processes. The former extend outward and have several sharp prongs; the latter have three small teeth near the tip. This operculum is a modification of two of the branchial filaments. The collar is ruffled and is divided by the ventral groove into two symmetrical lobes, each of which bears a chalky-white spot.

This animal builds a convoluted calcareous tube, smooth and porcelain-like within. The interior is a deep lavender, shading to white at the rim. The colors of the animal itself are very striking. The branchiæ and antlers are deep carmine red; the operculum is yellow; and the body of the worm is flesh-colored. Contrasted with the white tube, this highly-colored annelid is decidedly showy. When disturbed, it quickly withdrawns into its dwelling. A number of specimens were found with tubes attached to the links of an old anchor-chain in English Harbor. Prof. A. O. Thomas kindly assisted in the work of collecting these specimens; but it was impossible to secure any perfect tubes, because they are curved and were so solidly cemented to the links of the chain. A number of embryos were found in the bottom of one of the tubes. Professor Nutting has described this annelid in his narrative.

Localities: Jamaica; English Harbor, Antigua; Florida.

Pomatostegus stellatus Schmarda

Plate VI, Figs. 9 and 10

This Serpulid is 55 mm. long, including the branchiæ, and it is 5 mm. wide in the thoracic region. The body is hemispherical in cross-section and has a wide ventral groove. The body is flesh-colored with yellow cross stripes shining like silk. The thorax includes 7 segments, each bearing setæ laterally. As in the specimen previously described the cirri of the thorax are modified into an undulating membrane used in smoothing the inside of the tube. In the present specimen, however, this membrane begins at the second thoracic segment, and without interruption it continues into the collar. The collar is very high and frilled; and in the ventral median line it is projected into a long, pointed triangular lobe, which lies between the two whorls of the branchiæ. The ventral shields are confined to this region.

The collar setæ are long and slender, slightly constricted and then enlarged just below the head of the main shaft. In the thorax the setæ are limbate and are of different lengths. The uncini in the thoracic tori are large and number about 12 to each torus. They are of the same shape in the abdominal region, but are fewer to a row.

The branchiæ are spiral, about a turn and a half. The filaments are bright rose color, lightly barred with white. The operculum in this specimen is yellow, and it has three vertical disks, united by a central vertical column. The number of disks varies from 3 to 5 in different specimens. The peduncle is wide and thin. Its edges are cutaneous and wing-like.

This worm builds a calcareous tube like that of *Spirobranchus*. It was found attached to the links of an old anchor-chain at English Harbor, Antigua.

Localities: Jamaica; Porto Rico; English Harbor, Antigua; Culebra.

Family *Sabellidæ*—Flexible tubes constructed of silk-like material with mud and sand.

Sabella melanostigma Schmarda

Plate VII, Figs. 4, 5, and 6

The body is 47 mm. long including the branchiæ. It is 6 mm. wide at its greatest breadth. It gradually decreases posteriorly. The body is compressed and has 130 segments. The color of the body is yellowish-brown. On the side of each segment there are two distinct black spots, one dorsal and one ventral to the setæ fascicles. These spots are larger anteriorly on the dorsal side, but reversed posteriorly, where they grow smaller and gradually disappear. There is a conspicuous black spot on the dorsal side of the buccal segment. They are also present on the dorsal basal lobes of the branchiæ. Under the microscope these spots seem to be pigment. Does this indicate the presence of eyes on the body?

The thorax has 9 segments. The ventral groove is missing on the thoracic plate. Except for difference in size the fascicles of setæ are like those of the abdomen to about the fifteenth abdominal segment, where the setæ change to just the one kind, namely—the blade-like form. The tori shorten here, and the uncini are small.

The setæ are a glistening yellow, very large and stiff. They are of two kinds, grading into each other from a spatulate to a simple blade. The latter are the longer and are dorsal. The uncini have a comb-like arrangement in the tori, the hooks pointing anteriorly. The posterior edge of each torus is widened into a membranous fin-like web. The uncini have a long shaft-like elongation and are capped with teeth.

The branchiæ are brown at the base, but the color soon changes to yellow. They are about 20 mm. long. The basal lobe is curved in and projects above the collar. There are 19 pairs of branchial filaments, which are nearly of equal length. Each filament bears 4 or 5 pairs of eye spots. The collar is low, with a gap between the lobes on both the dorsal and the ventral sides.

This specimen was found in a tide-pool at Needham's Point, Barbados. A group of these delicately tinted Sabellidæ thickly floored the tide-pool. They appeared to be similar in structure, but after close study several genera were found among them.

Localities: Jamaica; Barbados; Dry Tortugas; Ponce, Boqueron Bay, reef at Ponce, Mayaguez, Guanica Bay and Hucares.

Dasychone conspersa Ehlers

Plate VII, Figs. 1, 2, and 6

This beautiful little Sabellid could be seen under the water only at low-tide. Being very sensitive to stimuli, it would withdraw quickly into the tube upon being disturbed. The body is fuscous brown, irregularly sprinkled with dark spots. At the base the branchiæ are a reddish brown, shading to yellow at the tips. The branchial filaments are alternately crossed at irregular intervals by red and brown bands. The branchiæ are bilobed. They are situated on a short basal lamina, each bearing 19 filaments nearly equal in size except two smaller ventral ones. Each filament is closely pinnated. A short portion of the apex of each rachis is free from pinnules. On the back or outward aspect of the rachis there are two sets of sense organs in pairs and alternating with each other: (1) the black eyespots; (2) the smooth whitish filaments, probably tactile in function.

The body, including the branchiæ, is 26 mm. in length. The greatest width, which is at the third segment, is 3.5 mm. The body narrows anteriorly, and posteriorly it decreases to almost 2.5 mm., but widens a little before coming to a blunt end. There are 87 segments. In general the body is flattened except in the thoracic region, where it is strongly arched dorsally and flat ventrally. There are 4 buccal tentacles: 2 short triangular dorsal ones and 2 narrow elongated ventral ones. The buccal segment is short and is fortified by a small bundle of setæ and a ventral shield. The collar is low and in 2 lobes, gaping wide dorsally and meeting ventrally. The lobes are slightly elongated and triangular. On the ventral side in the posterior region there is an elongated trough-like depression, extending through about 20 segments. In the bottom of this depression lies the ventral groove, which extends forward to about the ninth segment. The ventral shields of the 9 thoracic segments are dilated anteriorly into acute angles.

The setæ, which are brown in color, are stout with a broad border. They are alike in both regions except for size, being larger in the thoracic region. In this region the tori extend from the setæ fascicles to the shields. The abdominal tori are much shorter. The uncini are of the same shape throughout, but are smaller in the abdominal region. They are S-shaped, and on the terminal curve of the hook they are armed with a few teeth. They are in single rows. The dark spots between the bundles of setæ and between the tori are larger in the thoracic segments.

The light brown tubes are thin, fragile, and paper-like in texture. On the outer side they are covered with a fine gray mud.

Localities: Jamaica; Key West; Falmouth Harbor, Antigua.

Parasabella sulfurea Treadwell

Plate VII, Figs. 7, 8, 9, 10, and 11

The specimen here described is 67 mm. long, 18 mm. of which is in the length of the branchiæ; it is 5 mm. wide at its maximum breadth, tapering posteriorly to a sharp point. It is quite flat and arched slightly on the dorsal side. The color of the body is a pale purplish-brown, shaded deep in mid-dorsal line. At the base the branchiæ are purple, gradually shading to a lavender, and merging to yellow at the tips. The branchiæ rise from a rounded base and have no inrolling on the dorsal side. A short portion of the distal end of the rachis is naked (no pinnæ). The slender filaments are webbed at the base. There are about 15 pairs. Just beyond the web and extending more than half way, each filament bears on either side of its outer surface a row of minute purple spots.

The collar is low and the ends widely separated dorsally, but nearly in contact ventrally. Each ventral lobe is pad-like, or thickened. The edge is recurved. The torus of the first segment is arranged obliquely posterior to the dorsal free end of the collar. The torus is lateral and ventral to the setæ fascicles in the thoracic region. The latter includes 9 segments. Beginning with the abdomen and extending throughout the remainder of the body, the torus is ventral to the setæ fascicles. The setæ of the first setigerous segment are of two kinds: one is long, slender, and shaft-like, with the apex bent and narrowed to a point; the other is stout, with apex rounded and covered with spines, and terminating in a short, slender point. The setæ are of two kinds: slender forms with curved apex, the bent portion having spines; and stouter forms with rounded ends. The uncini in the torus are arranged in a single row in comb-like fashion. They are S-shaped.

Specimens of these tube-dwelling worms were found inhabiting mud tubes in a tide-pool at Barbados.

Localities: Dry Tortugas; Barbados.

? *Bispira melania* (Schmarda)

Plate I, Figs. 1 and 2; Plate II, Figs. 1, 2, 3, and 4; Plate III, Figs. 1 and 2; Plate IV, Figs. 1, 2, 3, 4, 5, 6, 7, 8, and 9

Following a recent determination of Professor Treadwell's the writer is placing this specimen provisionally in *Bispira*. She, however, has never read a description of this genus and is therefore unable to verify the assignment. Schmarda describes the species in question as *Sabella melania* in the following manner:

Sabella melania Schmarda

Taf. XXIII. Fig. 192

Char.

Die Farbe des Körpers ist ein dunkles Braun, beinahe schwarz; die Kiemen sind heller, die Fädchen abwechselnd schwarzbraun und gelbbraun. Die Länge des Körpers ist 150 mm, ein Drittel davon auf die Kiemen (46:100). Er zahlt 144 Ringe. Die Borsten der sechs oberen grossen Bündel und die folgenden zeigen nur Kleine Grossenunterschiede. In allen sind zweierlei Borsten, die einen haben parallele Conturen, die andern haben den einen Rand unter einen sehr stumpfen Winkel gebogen. Die Hakenborsten sind S-formig, leicht gestreift. Die Rohren bestehen aus Schlamm.

Port Royal in Jamaica, in einer Tiefe von 2-10 Meter, gesellig beisammen.

These tube-dwelling worms are found on the old sea-wall surrounding the Dockyard at English Harbor, Antigua. With their plumy, graceful, vari-colored branchial crowns extending above the tubes, they present a gorgeous spectacle like an extensive submarine mural flower garden. Appearing just above sea-level, they continue in a solid mass almost to the bottom of the sea-wall. The numerous closely-set branchial filaments have a spread of 8 to 10 inches. They are beautifully colored in shades of brown with several series of color spots forming bands, the color combinations being fuscous brown banded with light tan spots, chocolate brown banded with white, dark purple with brown spots, and dark mahogany red banded with light brown. A few are almost white with indistinct barring like watered silk. This wonderful display of delicate feathery filaments in beautifully blended colors was a source of constant admiration to all the members of the expedition.

DESCRIPTION

External Features

The entire length of the specimen here considered is 120 mm., of which 90 mm. is in the length of the branchiæ. The body in the contracted condition measures 110 mm., but in life it could be extended to a much greater length. The maximum width is 20 mm., and the maximum thickness is 15 mm. The body is hemispherical in cross-section. The ventral side is flat, but the dorsal side is strongly arched. There are about 180 segments. The color of the dorsal side of the body is a reddish-brown, with a dark spot on each side of the segments just above the tori, which are a tan-brown. The ventral side of the body has a median band, 10 mm. wide, the color of which is a deeper reddish brown than that of the dorsal side. The lateral margins are of the same color as that of the dorsal tori. The bundles of yellowish setæ are closely set, appearing like a yellow stripe along the sides of the body.

The body is divided into head, thorax, and abdomen. The prostomium is compressed and bears two kinds of sense-organs; dorsal tentacles, two in number, and palps. Each palp is represented by a number of long, mobile filaments, arising from a common base which is set on an E-shaped lophophore. The branchial crown is nothing more than the greatly subdivided and enormously elongated palps. There are 80 branchial filaments, which are united near the base by a delicate web. Each filament is provided with secondary processes, called pinnæ. In addition to its sensory functions, each filament aids in conveying food to the mouth by the action of the pinnæ. The branchiæ are respiratory organs. The peristomium does not bear setæ or cirri, and it is reflexed to form a collar, which is two-lobed. The ends are widely separated on the dorsal side, while on the ventral side they are in contact. Each ventral end is prolonged into a triangular recurved lobe.

The thorax has 8 segments. The torus of the first segment is arranged obliquely just posterior to the dorsal free end of the collar on either side.

On the next 7 segments the torus is lateral and ventral to the setæ tuft. The thoracic segments are provided with shield glands, which are continued down the abdomen along the ventral groove.

The abdomen begins on the ninth segment, and throughout the remainder of the body the torus is dorsal to the setæ tuft, or fascicle. On reaching the thorax the median ventral groove bends to the left and is continued along the dorsal surface to the head. This groove is ciliated and serves to carry the fæces out of the tube. The parapodia are not well developed.

The setæ fascicles on the thorax are like those of the abdomen, only much larger. There are two kinds of setæ: the one is shaped like a long, slender shaft, the apex being slightly bent and narrowing to a point, and it is lightly striated; the other is broader with a sharp angle at its maximum width, from which it gradually tapers to a point. The uncini in the tori are sharply curved hooks, S-shaped and lightly striated.

Internal Anatomy

Literature on the internal anatomy is exceedingly scant. Descriptions are confined to external characters. Nereis is usually taken as a type for the Polychæta, but it is an errant carnivorous animal and differs from the sedentary and herbivorous forms.

Digestive System. The mouth is anterior and opens into the buccal cavity. There are no jaws. Eversion does not take place in this form. The œsophagus (pharynx), (Plate V, Fig. 1) is surrounded by a thick muscle. It protrudes into the stomach. The stomach is very large, extending through segments 2-7. In segments 4-7 the sides are deeply infolded so as to make a series of chambers connected by comparatively narrow openings. This region also has numerous small, short cœca. The intestine (Plates VI and VII, Figs. 1, 2, 3, 4) is coiled, one full turn to three or four segments, or metameres, though this seems to vary. Anteriorly there are numerous cæca of all sizes, and these seem to alternate with radiating masses of chlorogogen; posteriorly the cæca are fewer and smaller, and the chlorogogen is more abundant, completely filling the cœlome. The anus is terminal.

Septa. These are apparently complete or nearly so in the abdominal region, but not in the thorax. Most of them seem merely a layer of peritoneum, non-vascular, and fully transparent; but at intervals, more or less irregular, there are muscular partitions varying in thickness. There is a dorsal longitudinal mesentery suspending the coiled intestine. The septa (and mesentery) do not extend through the muscular layer, and it is not always easy to correlate the segments with the external rings. The septa of the fifth and sixth segments are very vascular.

Muscular System. There is a uniform, continuous layer of circular muscle, vascular, separated from the longitudinal layer by a fairly thick layer of connective tissue. The longitudinal layer is divided into three longitudinal bands, one dorsal and two ventral. (Plate VI, Fig. 1). The setæ muscles were not investigated. The pharynx (œsophagus) is very muscular.

Circulatory System. In the abdominal region there is no dorsal vessel. One specimen had a dark line visible externally in the mid-dorsal region extending more than half way back, but investigation revealed no vessel. At any rate the muscular layer is too thick to permit such a vessel to be seen externally. The dark line was apparently due to a concentrated plexus of small vessels in the circular muscle layer. Other specimens do not show it. The chlorogogen masses of the intestinal region support a rich circum-intestinal plexus, that no doubt takes over the function of a dorsal vessel. (Plate VI, Fig. 1). There is a very conspicuous ventral blood vessel (Plate VI, Figs. 1 and 2) suspended by a longitudinal mesentery; circular vessels are present. In the thorax (Plate VIII, Fig. 1) a dorsal vessel is developed, and the five anterior metameres contain each a pair of large, thick-walled "hearts." (Plate VIII, Fig. 1). Whether these connect with a ventral vessel was not determined. The sixth and seventh thoracic segments have no "hearts," but the septa are very vascular. This vascular condition of the septa is also found in the anterior abdominal metameres, and one specimen showed a large sinus filled with blood so located as to simulate a "heart."

Nervous System. The ventral nerve cord is of the ladder type, (Plate VIII, Fig. 2). There are no discernible gangliar enlargements. Directly above each hemisphere of the cord is a large hollow vessel (Giant fiber?). This hollow vessel is also found in the brain, which is located in the extreme anterior tip just above the mouth. (Plate V, Fig. 1) The nerves of the cord are large and regular, extending out at right angles.

Excretory System. The cœlome in the thoracic region is filled with gray, glandular tissue, taking the form of much lobulated sacs. Whether these form one or several nephridia is not clear. They fill the cavity of each metamere; and a portion extends forward into the head, where the two sides unite into a common external opening just above the brain. (Plate) V, Fig. 1). Whether or not there are nephridia in the abdomen it is difficult to determine.

Reproductive System. Not identified. Probably consists of gonads that are inconspicuous except in the breeding time.

The Tube

The tube is made from a secretion from the ventral shield glands. This secretion serves to stick together fine particles of mud so as to form a cylindrical tube, which is lined internally by the hardened mucus. As the animal grows, the tube is lengthened by building on at the anterior end. The animal revolves in the tube, while the pinnæ of the branchial filaments collect the particles of mud. The animal, rising partly out of the tube, uses the collar lobes as trowels which beat down the thin edge as they fold and clasp over the margin. The longest tube collected measures 190 mm.

When the animal is undisturbed, the branchiæ always protrude from the tube. At night they are only partially extended from the tube, though not expanded as during the day. Hundreds of specimens of this tube-dwelling annelid were collected. It is necessary, however, to use great caution in capturing this worm, as it immediately withdraws into the tube if a shadow falls upon it or if the water is disturbed by the motion of oars. It is also necessary to work quickly; for the tube is of considerable length, and the inhabitant withdraws to the bottom of it and sometimes even escapes through the posterior end of the tube.

Localities: Port Arthur, Jamaica; English Harbor, Antigua.

CONCLUSION

It is the opinion of the writer that the species of *Bispira* just described was introduced at English Harbor, Antigua, probably at the beginning of the nineteenth century, when Nelson used the island as a naval base. These worms are found along the sea-wall at only one place on the island, namely, the dockyard where ships anchor. These sedentary tube-dwelling annelids might easily have been carried long distances attached to the bottom of ships or to anchors.

This annelid, being a tube-dwelling worm, has the body highly specialized anteriorly, while posteriorly some degeneration has taken place. The parapodia are greatly reduced along the entire length of the worm. Dissections show that the septa are incompletely developed in the thoracic region, and sometimes they are absent near the head. Absence of septa allows a free communication between successive segments and consequently a freer flow of cœlomic fluid. With the disappearance of the septa there is a diminution in the number of nephridia. The cœlome in the thoracic region is filled with gray glandular tissue which seems to be nephridia. A large portion extends forward into the head, where the two nephridia unite into a common external opening just above the brain. In the abdominal region there is no dorsal blood vessel. It seems to be replaced by a sinus. The ventral blood vessel is very conspicuous. The intestine is very much coiled. This is contrary to the usual type, which has a straight intestine. Probably this feature is due to the mode of life, as the worm is chiefly a vegetable feeder. The coils in the intestine give greater area for absorption.

Evidences of regeneration are shown in a number of specimens. One large worm that had lost its greatly specialized branchiæ had started to grow a new crown. Other specimens that had a few of the branchial filaments torn away were re-placing them by a new fringe. Another specimen that had lost its posterior region was growing a new tail. Sir J. Dalyell noted in *Dasychone* that in the springtime the branchial crown was regenerated in about a month, while in winter a longer time was necessary. He also cut a *Dasychone* into three pieces. He reports the regeneration of parts as follows: "The hindermost produced a head, the anterior piece developed an anus, and the middle portion formed both head and tail!" This extensive power of regeneration is of extreme value to the Polychæta.

The species identified and described in this paper seem to be peculiar to the tropical regions. In Vol. XII of the "Harriman Alaska Expedition Reports" Miss Katharine Jeanette Bush in her report on the "Tubicolous Annelids of the Tribes Sabellides and Serpulides from the Pacific Ocean" does not record any of the species herein noted. Neither does J. P. Moore mention any of the species of these groups in his report of the "Sabellidæ and Serpulidæ from Japan." Prof. A. L. Treadwell, however, reports some from Porto Rico, Dry Tortugas, and the Bahamas. E. Ehlers has recorded and described a number from the Florida region. Ludwig K. Schmarda reports on some from Jamaica, and J. E. Benedict includes some in a report from Bermuda.

In considering the group as a whole the Leodicidæ has the greatest number of genera represented. There are perhaps eight to ten genera, but in many instances there is only one specimen to a species. In number of individuals Sabellidæ surpasses all other groups, as there are hundreds of specimens in several of the species collected.

ADDENDUM

In the foregoing pages the writer has stated that she had been unable to find a description of the genus *Bispira.* Since this paper has gone to press, however, she has received through the Library of the University of Iowa a copy of "The British Marine Annelids, Volume IV, Part II, Polychæta, Sabellidæ to Serpulidæ," written by Professor W. C. McIntosh and published by the Ray Society, London, 1923. In a short discussion of the genus *Bispira* Professor McIntosh states that the "branchiæ arise from a a firm spiral base, and have . . . ocular spots on the outer edge.'' The specimen provisionally classified as *Bispira melania* does not have a spiral formation or ocular spots. If the presence of ocular spots is a generic character, this form does not fit in the genus *Bispira.* Professor A. L. Treadwell has kindly suggested following R. V. Chamberlin's classification in his monograph on the Pacific annelids, as his diagnostic generic characters seem very accurate; but to date the writer has not been able to secure this reference.

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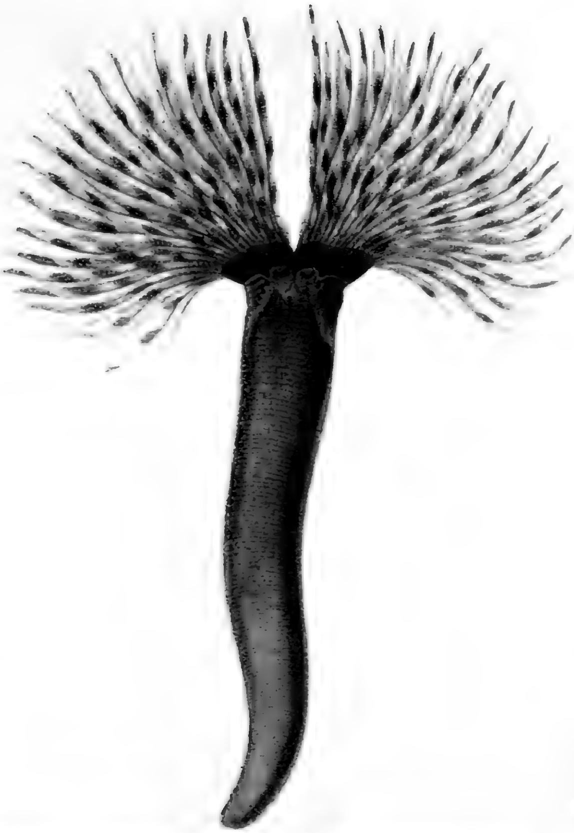

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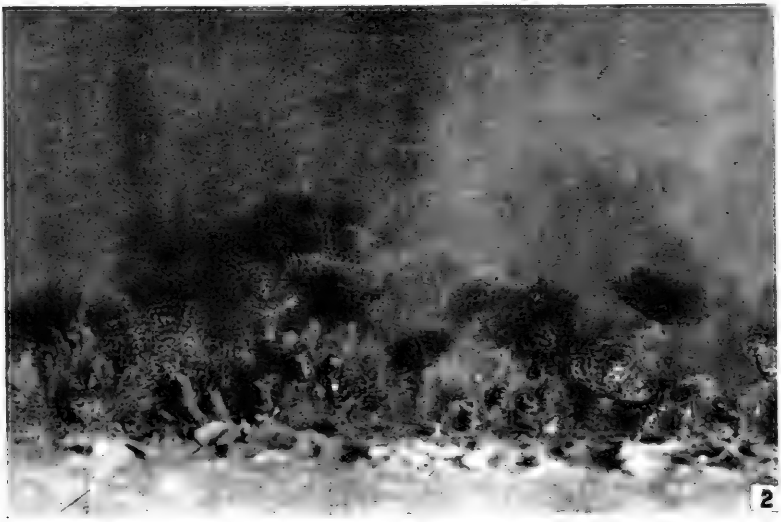

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PLATE I

? Bispira melania

Fig. 1. Dorsal view—branchiæ expanded

2. Tube-dwellers in their natural habitat on the sea wall at English Harbor, Antigua

PLATE II

? Bispira melania

Fig. 1. Specimen without branchiæ

2. Specimen showing branchiæ regenerating

3. Ventral view—branchiæ folded

4. Branchial filaments

PLATE III

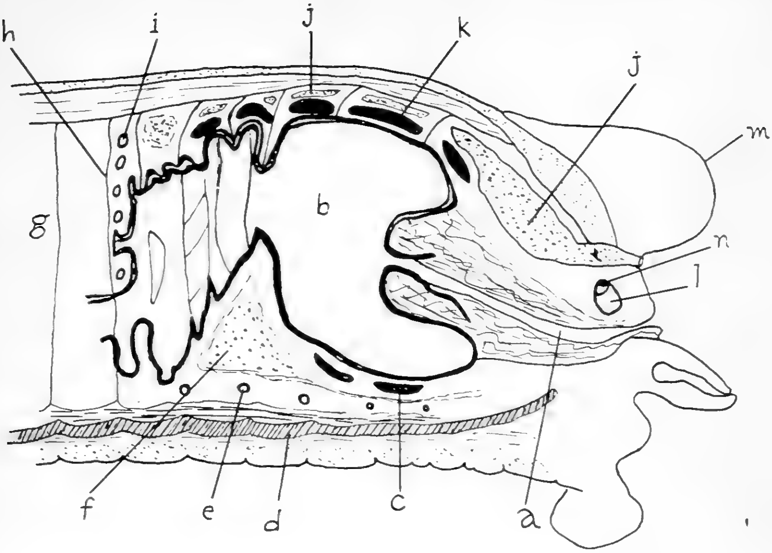
? Bispira melania

Fig. 1. Median longitudinal section through thorax
Partly diagramatic (hearts are not cut) x 4

a Œsophagus
b Stomach
c ''Hearts''
d Nerve cord
e Blood vessel
f Nephridium
g Abdominal region
h First complete septum
i Coeca
j Nephridium
k ''Hearts''
l Brain

Fig. 2. Cross-section in region of intestine x 4

a Circular muscle
b Longitudinal muscle
c Dorsal longitudinal mesentary
d Blood vascular plexus
e Coil of intestine
f Intestine
g Setæ
h Ventral blood vessel
i Ventral groove
j Nerve cord
k Giant cells?
l Chlorogogen?



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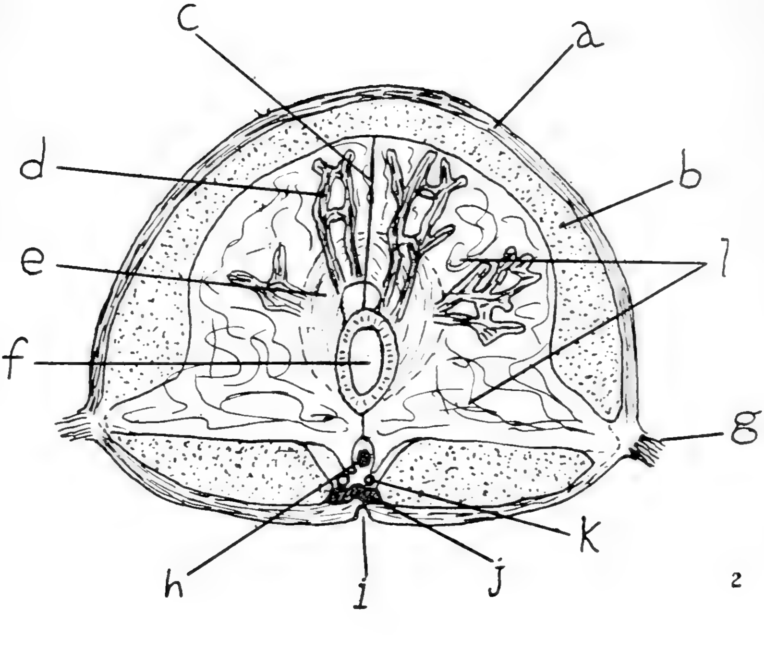

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PLATE IV

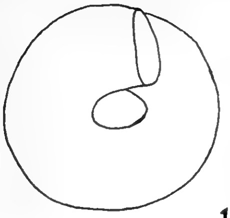
? Bispira melania

Fig. 1. Single coil of intestine seen from end
2. Coils of intestine seen from side
3. Diagram of "hearts"
   a Œsophagus
   b Stomach
   c Segments 1, 2, 3, 4, 5, 6, 7
   d Abdomen

Fig. 4. Section of anterior region of abdomen
   a Cœca
   b Intestine
   c Chlorogogen

Fig. 5. Longitudinal section in region of intestine x 4
   a Circular muscle
   b Longitudinal muscle
   c Section of coiled intestine
   d Food in intestine
   e Septum
   f Section of cœcum
   g Sections of ventral blood vessel

Fig. 6. Portion of nerve cord
7. Setæ with parallel striations
8. Setæ with bent edge
9. Hooked setæ from torus



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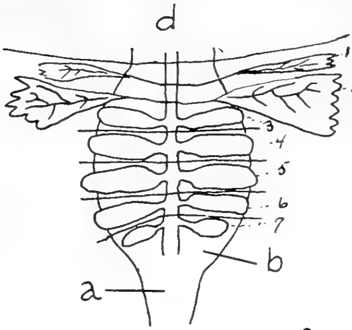

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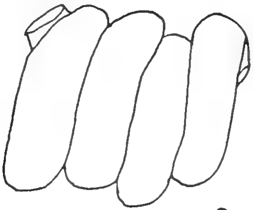

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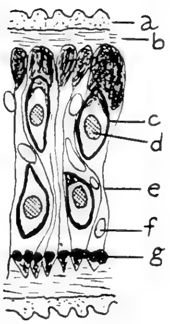

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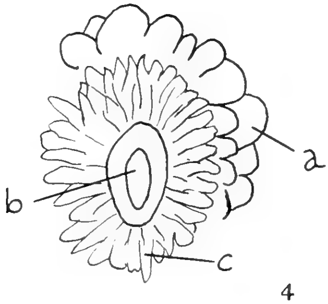

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PLATE V

? Bispira melania

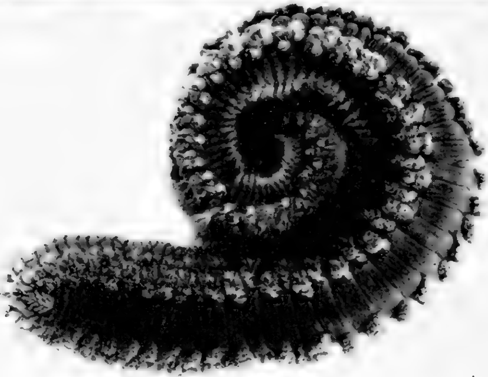
Fig. 1. Living specimens expanded; one specimen in a tube

Hermodice carunculata

Fig. 2. Dorsal view
3. Ventral view

PLATE V

1



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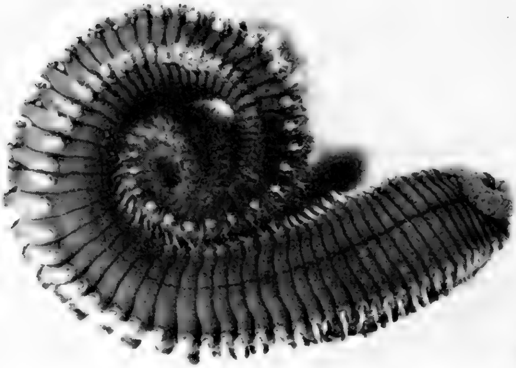

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PLATE VI

Eurythœ pacifica

Fig. 1. Parapodia with branchiæ

2. Seta

Hermodice carunculata

Fig. 3. Ventral parapodium

4. Dorsal parapodium showing branchiæ

5 and 6. Setæ

Spirobranchus giganteus

Fig. 6. Operculum

7 and 8. Setæ

Pomatostegus stellatus

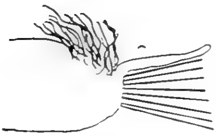
Fig. 9. Operculum

10. Seta

PLATE VI

1

5



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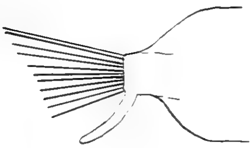

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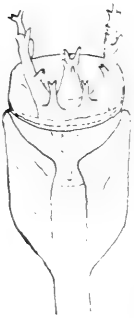

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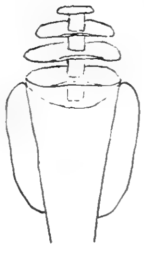

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PLATE VII

Dasychone conspersa

Fig. 1. Filament of branchiæ showing eye-spot and dorsal processes
2. Uncini from thoracic torus
3. Seta from thoracic fascicle

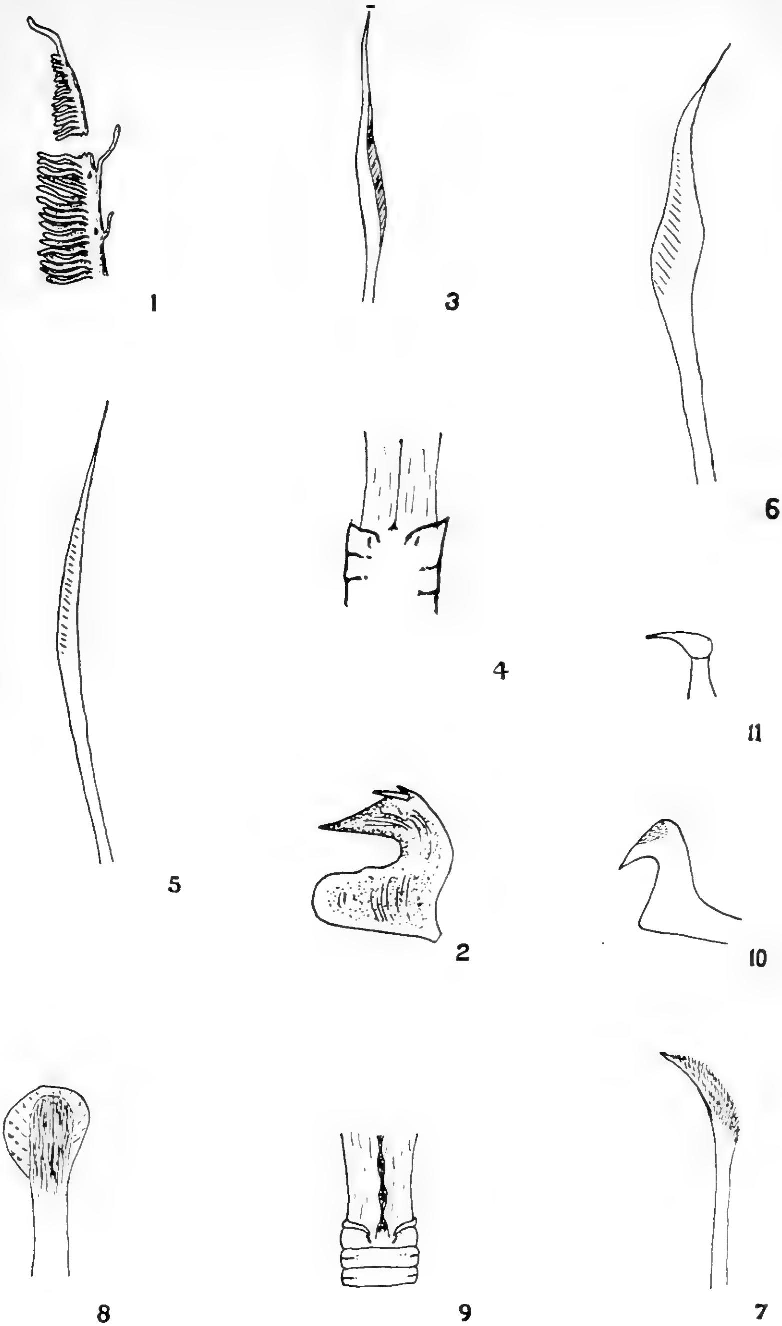
Sabella melanostigma

Fig. 4. Collar and base of branchiæ
5 and 6. Setæ (Greatly enlarged)

Parasabella sulfurea

Fig. 7. Slender seta from second segment
8. Rounded seta from second segment
9. Collar and base of branchiæ
10. Uncini thoracic torus
11. Pennoned seta accompanying uncini

PLATE VII



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of the Barbados-Antigua Expedition of 1918

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HENRY FREDERICK WICKHAM, M.S., Editor

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CONTENTS

POLYCHAETOUS ANNELIDS

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

A. L. Treadwell
Vassar College

The following is the result of a taxonomic study of the polychætous annelids collected by the Barbados-Antigua expedition, and submitted to me for examination through the courtesy of Professor Nutting. A tabulation of the families, genera and species represented follows:

Family	
Amphinomidæ	*Eurythoe pacifica* Kinberg.
	Hermodice carunculata Kinberg.
	Notopygos crinita Grube.
Polynoidæ	*Hermenia verruculosa* Grube.
	Halosydna leucohyba Schmarda.
	Halosydna fusca-maculata n. sp.
	Evarnella trimaculata n. sp.
Sigalionidæ	*Sthenelais grubei* Treadwell.
Acoetidæ	*Panthalis pustulata* n. sp.
Phyllodocidæ	*Phyllodoce oculata* Ehlers.
	Eulalia quinquelineata Treadwell.
	Eulalia foliosa n. sp.
Syllidæ	*Typosyllis corallicola* Verrill.
	Trypanosyllis vittigera Ehlers.
	Haplosyllis cephalata Verrill.
	Haplosyllis gula n. sp.
	Synelmis simplex Chamberlin.
Nereidæ	*Nereis glandulata* Hoagland.
	Nereis gracilis Webster.
	Nereis egregicirrata n. sp.
Glyceridæ	*Glycera abranchiata* Treadwell.
	Glycera dibranchiata Ehlers.
Leodocidæ	*Leodice binominata* Quatrefages.
	Leodice fucata Ehlers.
	Leodice mutilata Webster.
	Leodice caribœa Grube.
	Leodice longicirrata Webster.
	Leodice rubra Grube.
	Leodice tenuis Treadwell.
	Leodice spongicola Treadwell.

	Leodice rubrivittata Treadwell.
	Nicidion kinbergii Webster.
	Arabella setosa Verrill.
	Oenone diphyllidia Schmarda.
Cirratulidæ	*Cirratulus nigromaculata* Treadwell.
	Cirratulus melanacanthus Grube.
Maldanidæ	*Nicomache antiguensis* n. sp.
Terebellidæ	*Eupolymnia magnifica* Webster.
Sabellidæ	*Branchiomma lobiferum* Ehlers.
	Parasabella sulfurea Treadwell.
	Dasychonopsis conspersa Ehlers.
	Bispira melania Schmarda.
	Sabella melanostigma Schmarda.
	Hypsicomus purpureus n. sp.
Serpulidæ	*Protis sombrerianus* McIntosh.
	Spirobranchus tricornis Morch.
	Spirobranchus giganteus Pallas.
	Pomatostegus stellatus Abildgaard.

Family **Amphinomidæ**

Eurythoe Kinberg

Eurythoe pacifica Kinberg

Eurythoe pacifica Kinberg, (1857), p. 14.

Common in the collections. Ten specimens from Pillars of Hercules; nineteen from tide pool near Pelican Island; four "off the Crane"; also found in "old coral heads."

Hermodice Kinberg

Hermodice caruncudata Kinberg

Hermodice caruncudata Kinberg, (1857), p. 13.

Common in the collections. Found at Needham's Point and D.S.79 and 81, four specimens; Bathsheba, one specimen; Pillars of Hercules, eleven specimens; also at "sea beach at low tide" and "in old coral heads." Two small specimens measuring 15 mm. and 6 mm. in length respectively were taken at Station 99. From the character of the caruncle I concluded that they are the young of this species. The body in these is colorless but on the dorsal surface the intersegmental grooves are marked by heavy black, transverse lines.

Notopygos Grube

Notopygos crinita Grube

Notopygos crinita Grube (1878), p. 7.

Collected at "sea beach at low tide" one specimen, and Pillars of Hercules two specimens.

Family **Polynoidæ**

Hermenia Grube

Hermenia verruculosa Grube

Hermenia verruculosa Grube, (1856), pp. 45, 46.
Treadwell, (1911), pp. 9 to 14, figs. 23 to 26.

One specimen collected at Station 101.

Halosydna Kinberg

Halosydna leucohyba Schmarda

Halosydna leucohyba Schmarda, (1861), p. 153, text figs. a, b, c; pl. XXXVI, fig. 308.
Webster, (1884), pp. 309, 310, pl. VII, figs. 19, 20.

One specimen "on old coral heads."

Halosydna fusca-maculata new species.

A single specimen is in the collection. In the great difference in size between the first pair and later pairs of elytra this approaches *Hermenia* of Grube, but the number of elytra is greater and the differences in size less marked than in the single species thus far described in that genus. The animal is 28 mm. in length with a width of 5 mm.

The prostomium is about as wide as long, with the anterior margin prolonged to form the bases for the lateral tentacles. (Figure 5) The anterior eyes are larger than the posterior, have evident lenses and are situated slightly ventrolaterally so that from the dorsal view they are covered by a little tissue. The cirrophore of the median tentacle is relatively rather broad and fills the anterior cleft of the prostomium. The terminal joint is much more slender than the cirrophore. The lateral tentacles are similar in form to the median. All tentacles terminate in very fine apices without any trace of a sub-terminal enlargement. In the type and only specimen the right palp is larger than the left but neither is very large, and their surfaces are smooth and without papillæ. The tentacular cirri are absent on the left side. Those of the right side show the dorsal one larger than the ventral, about as large as the left palp but more slender. Both have fine tips.

The left first elytron is present. (Figure 6) It is broadly oval in outline and translucent with no trace of color. Its inner margin extends to the median line of the prostomium and anteriorly it covers the bases of the lateral tentacles and tentacular cirri, while posteriorly it covers the first and second parapodia. In the entire animal the two first elytra must have together covered the entire dorsal surface as far back as the first two setigerous somites. The first setigerous somite is wider than the prostomium and later ones increase in width so that in the preserved material, setigerous somite 5 is three times as wide as the prostomium.

The second elytra have hardly one-half the width of the first and this together with the increase in the width of the body, makes these elytra able to cover only a very small portion of the dorsal surface; hardly more than the bases of the parapodia. (Figure 7) Elytra 2 to 6 have dark-brown margins which makes them easily recognized but later ones are without color and so translucent as to be easily overlooked. The dorsal cirri have heavy cirrophores but their terminal joints are small.

A parapodium from near the middle of the body (figure 8), has two aciculæ, one extending into the setal lobe and the other into a small rounded dorsal lobe which must be the much degenerated notopodium and bears no setæ. The cirrophore of the dorsal cirrus is very large, broader at the base than is the setal lobe and is about as long as this lobe. At the apex it carries the small lanceolate dorsal cirrus. The setal lobe is obliquely truncated at the apex and the setæ are all alike each with a stout shaft tapering to a bluntly rounded apex. In the parapodium figured those dorsal to the aciculæ had a sub-apical tooth, those ventral to it had not. I am uncertain if this is the case in all somites. Each seta has, arranged basally from the apex, rows of flat plate-like teeth with finely denticulated edges. (Figure 9) There is a very small ventral cirrus.

The specimen retains one anal cirrus in form like the dorsal but shorter and more slender.

Collected at Barbados.

The type is in the Museum of the State University of Iowa.

EVARNELLA Chamberlin

Evarnella trimaculata new species

A single specimen collected at Station 101. The body is 15 mm. long, 3 mm. wide without the parapodia, has 35 somites and 15 pairs of elytra. It is characterized by three prominent brown patches on each elytron and a brownish band on each inner elytral border.

The prostomium (figure 1) has nearly a square outline with peaks blunt and radiating. The anterior eyes are the larger, situated dorso-laterally at the bases of the peaks. The posterior eyes, much smaller and very black, lie near the posterior margin.

The median tentacle is lost but its cirrophore is large and fills most of the space between the peaks. The cirrophores of the lateral tentacles extend about as far as that of the median. Each lateral tentacle narrows abruptly at about its middle forming a long slender filamentous terminal half. The palps are unusually short, hardly more than twice as long as the lateral tentacles.

Except for size the elytra are all alike. They are translucent white with smooth contours and a large number of small blunt spines are scattered over rather less than one-quarter of their area, toward the anterior border. (Figure 2). Each elytron has three pigment patches, one on either side of the point of attachment of the elytrophore and one near the outer margin. When the elytra are in place the pigment patches extending in a row outward and slightly posteriorly in each somite are a marked feature of the dorsal pigmentation. In addition to these each elytron has a band of pigment running parallel to its inner margin with more or less pigment shading away from this band on either side.

A parapodium from near the middle of the body (figure 3) has a bluntly conical setal portion with a short anterior lip at the apex. The dorsal cirrus is slender without any special markings and arises from a very stout cirrophore placed posterior to the dorsal seta-tuft. A small acicula extends into the dorsal portion of the parapodium and a much heavier one lies in the setal lobe. The ventral cirrus is very slender. On the dorsal surface of the parapodium is an elevation corresponding to the elytrophore of the elytra-bearing somites.

The dorsal setæ are stout and only a very little curved toward the blunt apex. Each has many rows of spines which have the form of transversely arranged plates which according to the position of the seta look like a marginal row of fine teeth or else are seen along both margins of the seta-stalk and then look like two rows of teeth. The ventral setæ are very heavy and few in number in each parapodium. Each (figure 4) has a stout apex with a strong sub-terminal tooth. In the parapodium figure there were 9 of these ventral setæ, of which the 3 ventralmost were smaller than the others and without lateral plates. The 6 dorsalmost ones had the small plates shown in figure 4 each of which is finely denticulated along the free margin. In the position figured they appear as a row of marginal spines. If the seta is rolled so that the sub-terminal tooth is uppermost they show on both margins. The plates evidently are wider than the stalk of the seta.

The type is in the Museum of the State University of Iowa.

Family **Sigalionidæ**

STHENELAIS Kinberg

Sthenelais grubei Treadwell

Sthenelais grubei Treadwell, (1901), pp. 187, 188, figs. 10 to 13.

The original description was rather brief but there is no doubt as to the identification. In the original description it is stated that as far as somite 27 the elytra do not cover the dorsal surface. In this specimen the first five elytra cover the surface, the next eight leave a narrow uncovered area and behind this the surface is entirely covered. One incomplete specimen collected at Station 104.

Family **Acoetidæ**

PANTHALIS Kinberg

Panthalis pustulata new species

Three fragments evidently together comprising the entire body of the animal were in a bottle, but because of this broken condition measurements of length and counts of the number of somites and elytra are necessarily more or less inaccurate. The body length is approximately 115 mm. and the width without parapodia 11 mm. There are about 110 somites with at least 100 elytra.

The prostomium (figure 10) is oval in outline, barely 1 mm. in the transverse and rather more than that in the antero-posterior diameter.

The slender median tentacle is inserted in a dorsal groove which extends backward for more than one-half the length of the prostomium. On either side the prostomium is prolonged into a stalk, each stalk with a large eye at the end. A second, much smaller eye on either side lies a little in front of the middle of the prostomium. The lateral tentacles lie one beneath each eye-stalk and are approximately the same form and size as the median. The palps are fully ten times as long as the tentacles, each tapering to an acute point from a base which is one-half as wide as the prostomium. Scattered irregularly over the surface of the palps and much more thickly crowded together toward the apices are a large number of spiny processes most of which are irregularly conical in outline and an occasional one may be bifid. Figure 11 is a camera drawing of the profile of a palp taken near the apex. In addition to being more closely crowded together those toward the apices are larger than those found elsewhere.

Somite 1 (figure 10) is only a very little broader than the prostomium and its tentacular cirri closely resemble in form and size the antennae, though they are a trifle greater in diameter. The cirrophores of the tentacular cirri extend forward on either side to the level of the posterior margin of the anterior eyes.

The parapodia of the anterior somites (figure 12 is drawn from the 19th) have a heavy, obliquely truncated setal lobe with equal anterior and posterior lips. In the interior is a long rod of a brown chitin which extends into the interior of the body and has nothing to do with either the setæ or the acicula. A similar structure occurs in *Panthalis oculata* Treadwell (Treadwell 1901, pages 188, 189, figure 15). The dorsal cirrus has a heavy cirrophore and is itself thin-walled and conical, extending only a short distance beyond the setal lobe. The ventral cirrus is smaller than the dorsal but similar to it in outline. There is a single very heavy acicula. Beginning with somite 10 each parapodium has on its dorsal surface a series of thin-walled globular pustules. In somites with elytra the largest lie lateral to the elytrophore, though smaller ones may occur as far toward the dorsal surface as the base of the elytrophore. In other somites they are scattered irregularly over the surface of the parapodium (figure 12). From about the 50th somite backward these become more prominent, assume a cylindrical form with rounded ends and in the preserved material are decidedly an opaque white in color. Through a large part of the posterior region they have a regular arrangement. In the elytra-bearing somites there are two, lateral to the elytrophore on the dorsal surface of the parapodium. In the other somites there are also two, one on either side of the dorsal cirrus, lying, that is, one on the side toward the apex of the parapodium and the other toward the dorsal median line.

The very heavy acicula does not protrude from the surface of the parapodium. Dorsal to it in anterior somites is a row of slender colorless setæ which suddenly narrow toward the apex and carry along the narrowed portion a row of slender fine hair-like processes. (Figure 13)

At the bases of these setæ are numerous very short slender needle-like colorless setæ. Ventral to the acicula are two kinds of setæ. In the dorsal region of the tuft there are a few (6 in the one drawn) very stout yellow setæ with the apex slightly bent and blunt pointed. (Figure 14) Subapically each has a tuft of minute spines visible only under high power. Ventral to these is a tuft of colorless setæ each with a slender stalk which widens toward the end and then narrows to a very sharp apex, bending first to one side and then back to the original direction so that the terminal portion is parallel to the basal. (Figure 15) On either side of the entire terminal portion is a row of spines, (possibly a broad spine which extends entirely across the seta and shows on both margins.) Where these spines are largest they are obviously in the form of plates whose free margins are denticulated, and probably this structure persists in the smaller ones though this point is difficult to demonstrate.

Toward the posterior end the pustules on the dorsal parapodial surfaces described above change to finger-shaped or cylindrical lobes, but in other respects the structure of the parapodia is essentially as in the anterior somites and the same forms of setæ occur, though they are less separated into groups, the different types intermingling.

Most of the elytra had been lost. In life, they could hardly have covered the dorsal surface of the body. They are thin, delicate, translucent, approximately circular in outline with a wavy margin. Against a dark background all except the border is seen to be dotted with opaque white spots. In transmitted light these spots do not show.

One specimen collected at English Harbor. The bottle contained a thick walled tube of a soft, tough material coated on the outside by minute grains of sand. I am uncertain if the tube belongs with the animal.

The type is in the Museum of the State University of Iowa.

Family **Phyllodocidæ**

PHYLLODOCE Savigny

Phyllodoce oculata Ehlers

Phyllodoce oculata Ehlers, (1887), p. 135, pl. 40, figs. 4, 5, 6.

A single specimen doubtfully identified as this species though the characteristic dorsal lobes are lost and the general preservation is poor. The locality label was unfortunately lost in transferring.

EULALIA Savigny

Eulalia quinquelineata Treadwell

Eulalia quinquelineata Treadwell, (1901), p. 192, figs. 27 and 29.

One imperfect specimen, lacking both anterior and posterior regions. I have identified it from the five longitudinal dark lines on the dorsal surface and the three on the ventral.

Eulalia foliosa new species

A single imperfect specimen, probably collected at Station 101. The length is approximately 22 mm., the greatest width about 1 mm.

In the preserved material the dorsal surface of the anterior somites is very dark brown in color, with a narrow colorless band on either side just dorsal to the parapodium. At the posterior end this color disappears.

The prostomium (figure 16) is nearly circular in outline and has a pair of enormous eyes. The median tentacle arises between the eyes, is slender and about as long as the prostomium. The frontal tentacles are heavier than the median and are about as long as the prostomium. Only one tentacular cirrus remains and this is enormously broadened at the base, much flattened and curved backward lateral to the first somites.

A parapodium from the middle of the body (figure 17) is long and slender with a bifid presetal lobe of which the dorsal lip is the longer. There is a single acicula reaching the surface between the lips of the presetal lobes, and a ventral tuft of setæ. The only dorsal parapodial lobes remaining on the specimen are on the next to the last somite. They are slender-lanceolate in outline. The seta shafts are slender and obliquely truncated at the apex. Into the truncated portion fits the base of the terminal joint which is very slender, curves rapidly to an acute tip and is denticulated along one border. (Figure 18)

The type is in the Museum of the State University of Iowa.

Family **Syllidæ**

Typosyllis Langerhans

Typosyllis corallicola Verrill

Typosyllis corallicola Verrill, (1900), p. 603.

Two incomplete specimens collected at Pelican Island seem to belong to this species, though the greenish pigment cells which Verrill described on the cirri were not to be seen, and the œsophagus extended over 8 somites instead of 10 to 12, as in Verrill's material.

Trypanosyllis Claparède

Trypanosyllis vittigera Ehlers

Trypanosyllis vittigera Ehlers, (1887), p. 151, pl. 40, figs. 1 to 3.

A fragment of the posterior end of a syllid was collected at Station 101 and it is probably of this species, though in the absence of the anterior end it is not possible to be certain on this point.

Haplosyllis Langerhans

Haplosyllis cephalata Verrill

Haplosyllis cephalata Verrill, (1900), pp. 613, 614.

A large number collected in sponges at Falmouth, Antigua. The setæ showed decided tendencies toward a bifurcated apex.

Haplosyllis gula new species

Collected at Station 101 and when they reached me attached to the surface of fragments of *Leodice longicirrata* Webster; to a small Glycerid, and to another Syllid, though most of the specimens were on the *Leodice.* They were usually attached to the body wall rather than to cirri and evidently held in place by a strong sucking action of the pharynx for when pulled loose the point of attachment on the body wall showed as a very distinct papilla. Eisig (1906 page 180) and Potts (1911, page 410) have described the ferocity with which syllids attack other annelids and it is possible that the attachment took place in the close confinement of the collecting dishes rather than in the open ocean. I have elsewhere (1909, pages 359, 360) shown that *Haplosyllis cephalata* Verrill may establish a relatively permanent attachment to other annelids, for the cirrus held in the jaw of the syllid has evidently been digested. In the specimens here described there was no evidence of anything more than temporary attachment.

Under low magnification the most noticeable feature of the animal is the reddish-brown pharynx with its darker anterior margin which in all of the specimens was so far protruded that its anterior end was level with the anterior margin of the prostomium. (Figure 22)

One entire specimen has 32 somites with a pair of unjointed anal cirri (figure 23). The body is widest at the anterior end and gradually narrows posteriorly. The total length is about 2 mm. with a prostomial width of less than 0.25 mm. The palps are separate to their bases (figure 19), are together broader than the prostomium and are longer than it. The prostomium is short, its length being about one-third its width and its anterior margin is rounded. On either side are two reddish-brown eyes, the anterior of each pair larger than the posterior and considerably farther from the mid-dorsal line. Only the median and one lateral tentacle are present in the specimen figured and as this seemed to be the best preserved one of the lot, these are drawn. The median tentacle is a little larger and longer than the lateral and both are moniliform. The dorsal tentacular cirrus is about the size of the median antenna while the ventral one is very short, (not shown in the drawing). The first dorsal cirrus is larger and longer than the dorsal tentacular, and larger than most if not all of the other dorsal cirri, though there is not the decided decrease in length posteriorly which Verrill (1900, pages 613 and 614), described for *Haplosyllis cephalata.* The preservation is however too poor to allow of accurate description of most of the dorsal cirri. The parapodia are in length about equal to one-quarter of the body width and taper gently to the rounded ends. The ventral cirrus is lanceolate in outline and its length and breadth measurements are nearly equal to those of the parapodium.

The setæ are all alike (figure 20). Each has a rather stout sub-apical tooth and two very fine sharp-pointed apical teeth. Posterior somites have two setæ, anterior ones have three. The acicula is broader than the seta but no darker in color and is bent sharply at the apex, (figure 21). There is only one acicula to a parapodium and it comes to the surface at the base of the setæ.

The proventriculus and pharynx are both barrel-shaped and about equal to one another in length. The pharynx is reddish brown in color with the anterior margin much darker, and with a single anterior tooth. (Figure 22) The proventriculus (figure 22) has the usual arrangement of glands which appear white in reflected light but by transmitted light appear black because of their opacity. In the figure these glands are represented as larger and farther apart than they really are. When the pharynx is protruded as above described it and the proventriculus together extend as far as the fifth setigerous somite.

Co-types are in the Museum of the State University of Iowa.

Synelmis Chamberlin

Synelmis simplex Chamberlin

Synelmis simplex Chamberlin, (1919), pp. 177 to 179, pl. 28, figs. 1 to 5.

Two small specimens were in the collection but identification was made more certain through comparison with much larger specimens collected by myself in Tobago. The genus and species were described from two individuals collected at the Paumotu Islands and I was much surprised to find that in no respects did they differ from the West Indian specimens enough to justify the erection of a new species. The eyes which Chamberlin described as three or four on a side may be fused into a band considerably longer than broad and placed at an angle with the main axis of the prostomium. There is a small conical cirrus on the ventral surface of each palp near the anterior end, which Chamberlin did not mention. Chamberlin gives in his generic diagnosis "one pair of tentacular cirri" but this evidently means one pair on either side, for the latter is correct and it is so stated in the description of the species. There is an error in Chamberlin's key to the Subfamilies and Genera of the Syllidæ, page 165, where he puts *Synelmis* under AA; B, "tentacles and cirri articulated moniliform." They are all as stated in his later description, ovate with a constricted base and a slender apex.

The body is cylindrical with a very firm wall. In preserved material it is highly iridescent and the reddish segmental organs are very prominent. Because of this firm wall and cylindrical form and because the parapodia with their cirri and the tentacles are very small and inconspicuous, the animal when alive looks more like a nematode than a polychæte. This resemblance is heightened by the character of its movements which because of the elasticity of the body are quite similar to those of nematodes.

The proboscis was thrown out in most of my material from Tobago. It is stout, about 6 times as long as the prostomium and with a soft margin. The pharynx is very long.

Collected at Station 99, at Ft. Barclay and at English Harbor.

Family **Nereidæ**

Nereis Cuvier

Nereis glandulata Hoagland

Nereis glandulata Hoagland, (1919), p. 575, pl. xxx, figs. 1 to 6.

Five specimens and some immature ones that are evidently of this species were taken at Pelican Island; ten at Bathsheba, one at Pillars of Hercules, and one in "old coral heads."

Nereis gracilis Webster

Nereis gracilis Webster, (1884), p. 313, pl. IX, figs. 29 to 35.

One incomplete specimen in three pieces was taken at Station 99 and a young specimen at Pelican Island.

Leptonereis Kinberg

Leptonereis egregicirrata new species. Heteronereis phase

Small heteronereids not over 15 mm. long, which I have assigned to this sub-genus because of the absence of paragnaths. The prostomium is bent in all cases so that the palps point directly ventrally. The eyes are very large, purple in the preserved material and have prominent lenses. The tentacular cirri are rather short, the longest not reaching farther than setigerous somite 6 and the shortest barely longer than a somite. The longest is the postero-dorsal, the shortest is the antero-ventral.

The female (whose entire body is distended with eggs), has in the anterior region very feebly developed parapodia and those in the posterior region are small and closely pressed against the side of the body. Across the peristomium and the anterior 12 setigerous somites are traces of what must have been in life a prominent transverse band in each somite. Beginning on the 4th setigerous somite and continuing posteriorly there is a prominent pigment spot just dorsal to the parapodium on either side in each somite. Posterior to the 12th setigerous somite there is a tendency for the transverse band to break up, the apex of the band remaining on either side as a prominent spot. This results in the posterior region of the body in two rows of spots in each somite, the dorsalmost being the larger, with an irregular pigment row running across the dorsal surface of the somite.

Two varieties of male appear in the collection and agree so closely in the form of the tentacles, the eyes and the jaw structure that they certainly are of the same species. In one variety the dorsal cirri of the first 7 somites have the form characteristic of the male heteronereis, while in the other the 6th somite carries on either side an enormously elongated dorsal cirrus (figure 24). This has a much swollen base and a terminal joint extending to a distance at least 5 times the diameter of the body including the parapodia. Two individuals out of seven have this structure.

The jaws are light brown in color, are relatively very heavy and each has about 10 denticulations.

Collected by submarine light at English Harbor, Antigua. Type in Museum of the State University of Iowa.

Family **Glyceridæ**

Glycera Savigny

Glycera abranchiata Treadwell

Glycera abranchiata Treadwell, (1901), pp. 200, 201, fig. 49.

Two specimens collected at Pillars of Hercules and one on "old coral heads."

Glycera dibranchiata Ehlers

Glycera dibranchiata Ehlers, (1864-68), pp. 670 to 702, figs. 1 and 3 to 8.

One specimen collected on "old coral heads."

Family **Leodicidæ**

Leodice Savigny

Leodice binominata Quatrefages

Eunice binominata Quatrefages, 1865a, I, p. 327.

One specimen marked as collected in "old coral heads," Barbados.

Leodice fucata Ehlers

Eunice fucata Ehlers, (1887), p. 91, pl. 25, figs. 1-20.

Collected at Stations 25240, 25241, 25242, marked as from "old coral heads" but consisting only of fragments without any anterior ends; three anterior ends and many fragments from Pillars of Hercules; off the Castle, east side Barbados, fragments only; and one specimen from tide pool at Pelican Island.

Leodice mutilata Webster

Eunice mutilata Webster, (1884), pp. 315, 316, pl. IX, figs. 36, 36a to 36d, 40.

Two anterior ends and many fragments were collected at

Station 25242, fragments from the posterior ends from Pillars of Hercules, and fragments marked as from "old coral heads, Barbados."

Leodice caribœa Grube

Eunice caribœa Grube, (1856), p. 57.

One anterior end collected at Pillars of Hercules, several broken ends "from old coral heads," and one fragment from Station 99.

Leodice longicirrata Webster

Eunice longicirrata Webster, (1884), pp. 318, 319, pl. XII, figs. 75 to 80.

Fragments of two specimens were collected at Pillars of Hercules; one specimen from Bathsheba; young individuals from "old coral heads;" fragments from Station 90; and four young from Station 51.

Leodice rubra Grube

Eunice rubra Grube, (1857), p. 59.

Ten specimens collected at Bathsheba.

Leodice tenuis Treadwell

Leodice tenuis Treadwell, (1921), pp. 51 and 52, pl. 4, fig. 11; text figs. 154 to 163.

One incomplete specimen from Pillars of Hercules is probably of this species, though the pectinate setæ are not as prominent as they were said to be in the original description; the maxillæ are lighter and the mandibles darker in color than is there stated.

Leodice spongicola Treadwell

Leodice spongicola Treadwell, (1921), pp. 25 to 27, text figs. 53a to 53j.

One fragment of the anterior end, collected at Pillars of Hercules.

Leodice rubrivittata Treadwell

Leodice rubrivittata Treadwell, (1921), pp. 34 to 36, pl. 1, fig. 18, text figs. 85 to 94.

Two specimens collected at Fort Barclay, English Harbor.

Nicidion Kinberg

Nicidion kinbergii Webster

Nicidion kinbergii Webster, (1884), p. 320, pl. XI, figs. 81 to 88.

One specimen, collected at Pillars of Hercules.

ARABELLA Grube

Arabella setosa Verrill

Arabella setosa Verrill, (1900), pp. 651 to 653.

One specimen collected at Pillars of Hercules and two at Station 99.

OENONE Savigny

Oenone diphyllidia Schmarda

Oenone diphyllidia Schmarda, (1861), p. 120, pl. XXXII, fig. 256.

One incomplete specimen at Station 90 and one from "old coral heads."

Family **Cirratulidæ**

CIRRATULUS Lamarck

Cirratulus nigromaculata Treadwell

Cirratulus nigromaculata Treadwell, (1901), p. 204, fig. 66.

One specimen, collected at Pillars of Hercules.

Cirratulus melanacanthus Grube

Cirratulus melanacanthus Grube. Quoted from Ehlers, (1887), pp. 155, 156.

One specimen marked as collected "off Lord's Castle—Station 25256."

Family **Maldanidæ**

NICOMACHE Malmgren

Nicomache antiguensis new species

Fragments of two specimens were in one bottle labeled as collected at Pillars of Hercules. One fragment retained the prostomium and fourteen somites, the other the prostomium and five somites. An anal somite with eight attached somites was also in the bottle. It is impossible to tell to which of the two anterior fragments the anal somite belonged, but a comparison of the somites shows that they belong to the same species. A fragment of another specimen was collected at Pelican Island.

A lateral view of the prostomium (figure 25) shows a prominent anterior margin overhanging the mouth and extending to the sides of it but not continued posteriorly. The dorsal crest of the prostomium is rounded and extends through about a quarter of a circle. The nuchal organ is visible from the side as a depression near the antero-lateral surface of the prostomium. On a dorsal view the nuchal organs appear on either side as inverted V's with equal arms about one-third as long as the prostomium.

In preserved material the width of somite 1 is nearly twice its length; somites 2, 3 and 4 are equal to one another each being about one-third longer than somite 1. Somite 5 is three times as long as somite 4. In the one individual which retained them somites 6 to 8 are about equal to 5 in length, but 9 and later ones are much shorter and have thinner walls. All of the somites attached to the anal somite have very thin walls but their absolute length seems to depend on the character of the preservation.

Somites 1, 2 and 3 have on either side a row of stout hooks varying from 3 to 5 in number in the different somites. Dorsal and a little anterior to these hooks is in each somite a tuft of needle setæ. On somite 4 and later somites the place of the hooks is taken by a longer row of much smaller hooks and the dorsal seta-tuft is carried on a much more noticeable papilla.

A hook from somite 3 is shown in figure 26. It has a yellow color, darker at the apex and is slightly bent. The setæ of the dorsal tuft are very slender and sharp pointed, each with a noticeable wing on either side of the central axis, which does not continue to the tip of the seta.

On the 4th and later somites the hooks are much smaller and of an entirely different form from those in the first 3. Compare figure 27 with figure 26, where they are drawn to the same scale. Each of these smaller hooks has a swelling about midway of its shaft, a prominent subterminal tooth and a crest of four smaller teeth diminishing in size from the basal to the apical one. In the dorsal tuft of setæ is a form which I did not find in the earlier somites. Each has a central straight shaft with paired lateral plates whose free margins are toothed. These plates diminish in size toward the apex of the seta and are not found at the extreme end. A detail of the shaft is shown in figure 28. Slender setæ like those above described for somites 1 and 2 also occur in later somites.

In posterior somites the setæ and hooks are carried on much more prominent tori than anteriorly but the dorsal setæ are exactly similar to those of the anterior region. The hooks (figure 29) have more teeth on the crest and there is beneath the subapical tooth a tuft of chitin which seems to be solid rather than in the form of fine hairs as is the case with anterior hooks.

The anal funnel is deep and carries on its margin a row of about 22 slender subequal cirrus-like processes. One of these is bifid but this seems a difference of no significance.

The type is in the Museum of the State University of Iowa.

Family **Terebellidæ**

Eupolymnia Verrill

Eupolymnia magnifica Webster

Terebella magnifica, Webster, (1884), p. 324, pl. XI, figs. 58 to 60.

These belong in the genus *Eupolymnia* as defined by Verrill. They are common in the West Indian region, and the specimens in this collection are much smaller than those I have collected in the Dry Tortugas. A dense row of pigment spots on the collar was not noted by Webster.

Collected at Pillars of Hercules, English Harbor, Antigua;

and under rocks in English Harbor, the latter specimens incomplete.

Family **Sabellidæ**

BRANCHIOMMA Kölliker

Branchiomma lobiferum Ehlers

Branchiomma lobiferum Ehlers, (1887), pp. 254 to 259, pl. 53, figs. 10 to 15.

One specimen collected at English Harbor, Antigua.

PARASABELLA Bush

Parasabella sulfurea Treadwell

Parasabella sulfurea Treadwell, (1917), p. 267, pl. 3, figs. 20 to 23.

One specimen collected at Bathsheba.

DASYCHONOPSIS Bush

Dasychonopsis conspersa Ehlers

Dasychone conspersa Ehlers, (1887), pp. 266 to 270, pl. 54, figs. 1 to 6.

Since this species has dorsal appendages on the gills and a two-lobed collar it belongs in the genus *Dasychonopsis* rather than *Dasychone*. The specimens in this collection agree so closely with Ehlers' description that I have decided they belong in this species, though they are much larger and have a larger number of gills. Ehlers' specimens measured 26 mm. in length and had 19 gills. Some of these were 105 mm. in total length, the gills measuring 30 mm. and there were from 35 to 40 gills. It seems probable that the difference is due to age. Two specimens were collected at Pelican Island and two at Bathsheba.

BISPIRA Claparède

Bispira melania Schmarda

Sabella melania Schmarda, (1861), p. 35, figs. a, b, c, pl. XXIII, fig. 192.
Dasychone wyvillei McIntosh, (1885), pp. 501, 502; pl. XXXIa, figs. 1 to 3.

Schmarda's description is too brief to be of much diagnostic value, but so far as it goes it applies to these specimens except that he figures an uncinus without apical teeth. In all of my specimens these have apical teeth and McIntosh so indicates them in his figure 3. Schmarda's figure 192 agrees very closely with the appearance of the Barbados specimens. He figures about 24 rachides in each half of the gill, but as he is obviously intending to represent only one side of the animal the agreement is close, for the Barbados specimens have about 50 rachides in the gills.

Under the name *Dasychone wyvillei* McIntosh described a specimen from St. Thomas, West Indies. His specimen was without gills but in the general form and color of the body, the position of the anal opening, the character of the fæcal groove, the form and color of the collar, and the character of the setæ, his description applies accurately to the specimens under consideration. The only detail in which the resemblance is not close is that his figure 3, labeled as an anterior (thoracic?) uncinus, has a shorter manubrium than any I have seen, resembling in this respect more closely those of the abdomen.

The gills are prominent. Each half is inrolled at the base so as to form about three-fourths of a circle. There is a dark brown basal portion with a height of 5 mm. where the height of the whole gill is 50 mm. Beyond the basal portion each rachis is entirely free. Each rachis has bands of dark brown alternating with colorless regions. Where the color appears it is continued over the corresponding filaments. Through the middle of the rachides the filaments are six times as long as the diameter of the rachis, but toward the apex of the latter they are shorter and entirely disappear near the end, leaving the latter bare. There is no trace of either eye spots or appendages on the dorsal surface of the rachides but each has a shallow, pigmented groove along its mid-dorsal line.

Having no external appendages on the gills, having avicular uncini in a single row on all somites but the first thoracic, and the abdominal uncini having longer manubria than those of the thorax, these belong in the genus *Jasminiera* Langerhans, as that genus is ordinarily defined. Chamberlin however (1919, page 471) shows that *Jasminiera* should be replaced by *Bispira* Claparède, and that species having spiral gills which are ordinarily listed as *Bispira* should be transferred to the genus *Distylia* Quatrefages.

The animals may reach a size where the body length is 110 mm. the gills of such individuals reaching a length of 70 mm. The tube is composed of fine mud without much organic matter so that it breaks very easily. Its wall is about 1 mm. thick.

Over 70 individuals were in the collection mostly from English Harbor. Others were from sea wall, Dock Yard.

Sabella Linnæus

Sabella melanostigma Schmarda

Sabella melanostigma Schmarda, (1861), p. 36, figs. a and b, pl. XXII, fig. 190.
Ehlers, (1887), pp. 263 to 266.

I have based this identification largely on Ehlers' description, for while the specimens agree with the diagnosis given by Schmarda, they are, except for the presence of the dark spots, quite unlike Schmarda's figure 190. The figure shows a specimen entirely devoid of collar and is so aberrant that it seems certain that either an imperfect individual was seen or an error made by the artist. There seems to be some variability in the number of thoracic somites in this species, for Ehlers gives the number as 15 while these have from 10 to 13. As they are smaller than those seen by Ehlers the difference is possibly due to age. Hoagland (1919, pp. 577 and 578, pl. XXX, figs. 10 to 15; pl. XXXI, figs. 1 and 2), described from Porto Rico what she regarded as a variety of *Sabella melanostigma* and this had only 8 thoracic somites. In other respects these agree with Ehlers' description.

Associated with the thoracic uncini are series of inconspicuous pennoned setæ not described by either Schmarda or Ehlers but found by Hoagland in the Porto Rico material. The tubes are composed of a fine, light-gray mud. Abundant at Needham's Point, 3 specimens were taken at Falmouth Harbor and they are recorded as in "sand at low tide, Barbados."

Hypsicomus Grube

Hypsicomus purpureus new species

I have given this name to a fragment of *Hypsicomus* collected at Pillars of Hercules, English Harbor, Antigua. While only the gills, thorax and 11 body somites are present these are well enough preserved to show that they belong to a new species.

The bases of the gills are rather heavy and are in contact so that they give the effect of a cylindrical peduncle about eight times as long as the height of the collar. In the preserved material the color of this peduncle is purplish brown. At its base each gill rachis is colored much like the peduncle but this color rapidly lightens toward the apex. The rachides are about three times as long as the basal peduncle; are united by a membrane for about one-quarter of their length; their apices are blunt and devoid of filaments. The filaments in general are much lighter in color than the rachides, though toward the base of each gill there are several patches of darker filaments giving the gills a beaded appearance. On either side of each rachis extending not much beyond the middle of its length is a row of minute eye-spots.

The collar is very narrow with ends separated dorsally but ventrally they are nearly in contact. The ventral recurved flaps are bluntly triangular in outline and their tips extend only to about the posterior margin of the collar.

The body is too badly mutilated to allow of accurate description. On the right side of the thorax are seven rows of setæ and on the left only six.

In the dorsal tuft are two kinds of thoracic setæ. The longer (figure 30) extend for about one-third of their length beyond the shorter. Each has a central axis which is curved and sharp pointed at the apex with a marginal wing which is very broad at the bend, wider on the convex side and tapering to a very acute point. Ventral to these is a double row of palæiform setæ each (figure 31) with a very heavy stalk and a wing, forming when seen in full face a circular expansion entirely around the end. In profile the central axis is seen to bend slightly at the end and the expansion appears as a flat plate.

Ventral to these setæ lies a row of uncini with pennoned setæ at their bases. The uncini (figure 33) have a single large tooth and a very heavy base, with on the crest fine striations but nothing that could properly be called denticles. The pennoned seta (figure 32) has the head noticeably striated and a very fine point.

The abdominal setæ are of two kinds, both only slightly modified from those found in the thorax. The paleæ are quite similar to those of the thorax and the others resemble the pointed ones found in the thorax but are more slender with very long slender, sharp points.

The type is in the Museum of the State University of Iowa.

Sabellid genus and species?

From tide pool at Needham's Point was collected a fragment of a Sabellid too badly injured for identification, but it seems best to record what is possible on the chance that complete specimens may later appear. The gills are removed from the body. They are delicate, feathery, with no trace of eye spots. The collar is low, its ends separated widely dorsally but in contact ventrally, where each half ends in a short conical lobe. In the dorsal surface, anterior to the collar, are pigment patches. About 28 of the body somites are present and they all show the characteristic thoracic arrangement of setæ with simple setæ dorsally and uncini ventrally. The uncini are in a single row, each with a very long manubrium. There are no pennoned setæ. The dorsalmost setæ of the upper tuft are lanceolate at the apex, the ventral ones spatulate.

Family **Serpulidæ**

Protis Ehlers

Protis sombreriana McIntosh

Serpula sombreriana McIntosh, (1885), p. 515, pl. XXXIa, figs. 14 and 15.

A single specimen in its tube was collected at Dredging Station 1. One gill is lost but in the general structure of the body, the form of the collar, and the thoracic setæ, it agrees exactly with McIntosh's description. The thoracic uncini are, however, quite different from those figured by McIntosh for instead of having a row of small teeth they have but four increasing in size from the apex to the basal one which is very large.

I have provisionally identified this as *Protis,* for it lacks an operculum and is therefore not *Serpula.* I was, however, unable to find any collar setæ like those described by Ehlers as characteristic of this genus (Ehlers 1887, plate 56, figure 11) though forms like Ehlers' figure 12 are present.

Spirobranchus Blainville

Spirobranchus tricornis Morch

Spirobranchus tricornis Mörch, quoted from Ehlers, (1887), p. 292, pl. 57, figs. 8 to 15.

Spirobranchus giganteus Pallas

Spirobranchus giganteus Pallas, (1766), p. 139.
Ehlers, (1887), pp. 286 to 292, pl. 57, figs. 1 to 7.

Three specimens taken at English Harbor, Antigua.

Pomatostegus Schmarda

Pomatostegus stellatus Abildgard

Terebella stellata Abildgaard, (1789), p. 142.
Ehlers, (1887), p. 296.

Ehlers describes this species but gives no figures. He gives the measurements of his specimen as 24 mm. in length. One of the Barbados individuals is 90 mm. long with a thoracic width of 6 mm. Thirteen specimens were collected in tubes "growing in Millepores." No other locality was named.

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PLATE I

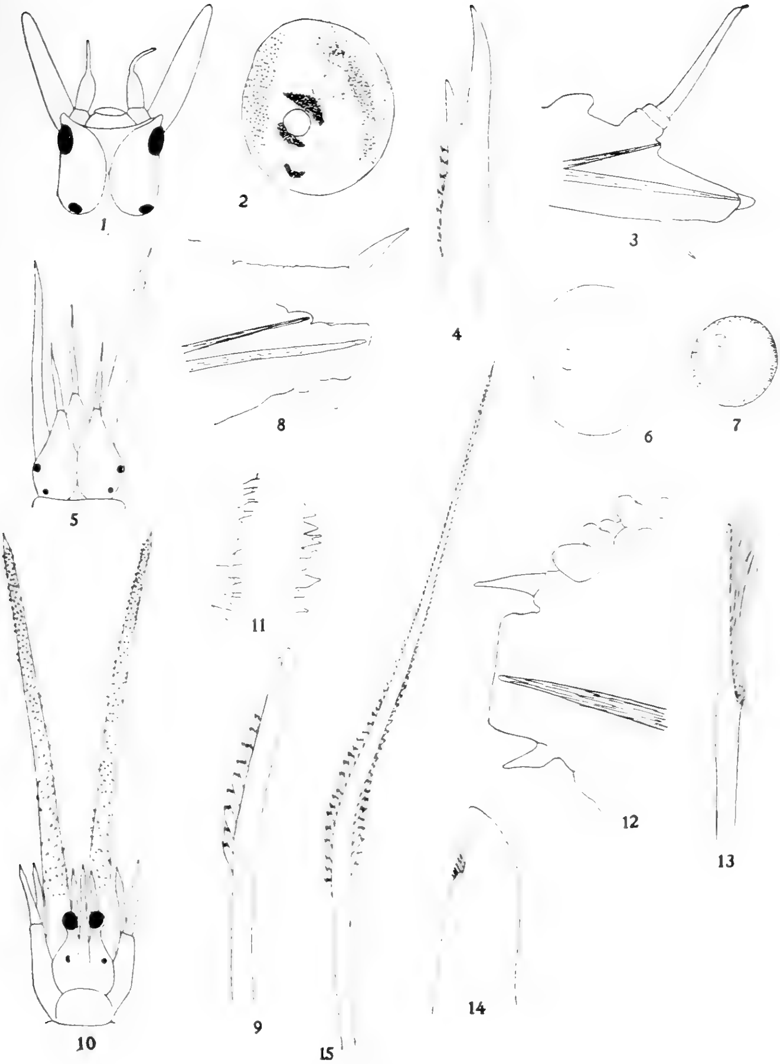

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PLATE I

Magnifications are somewhat less than stated below

Figues 1 to 4, *Evarnella trimaculata* new species. Figure 1, prostomium x 30; figure 2, elytron x 13.5; figure 3, parapodium x 17.5; figure 4, ventral seta x 185.

Figures 5 to 9, *Halosydna fuscomarginata* new species. Figure 5, prostomium x 10; figure 6, first elytron x 10; figure 7, second elytron x 10; figure 8, parapodium x 20; figure 9, seta from dorsal bundle x 185.

Figures 10 to 15, *Panthalis pustulata* new species. Figure 10, prostomium x 10; figure 11, outline of portion of palp near apex x 45; figure 12, nineteenth parapodium x 9; figure 13, seta x 370; figure 14, apex of large seta x 185; figure 15, seta x 250.

PLATE II

Figures 16 to 18, *Eulalia foliosa* new species. Figure 16, prostomium x 10; figure 17, parapodium x 20; figure 18, seta x 250.

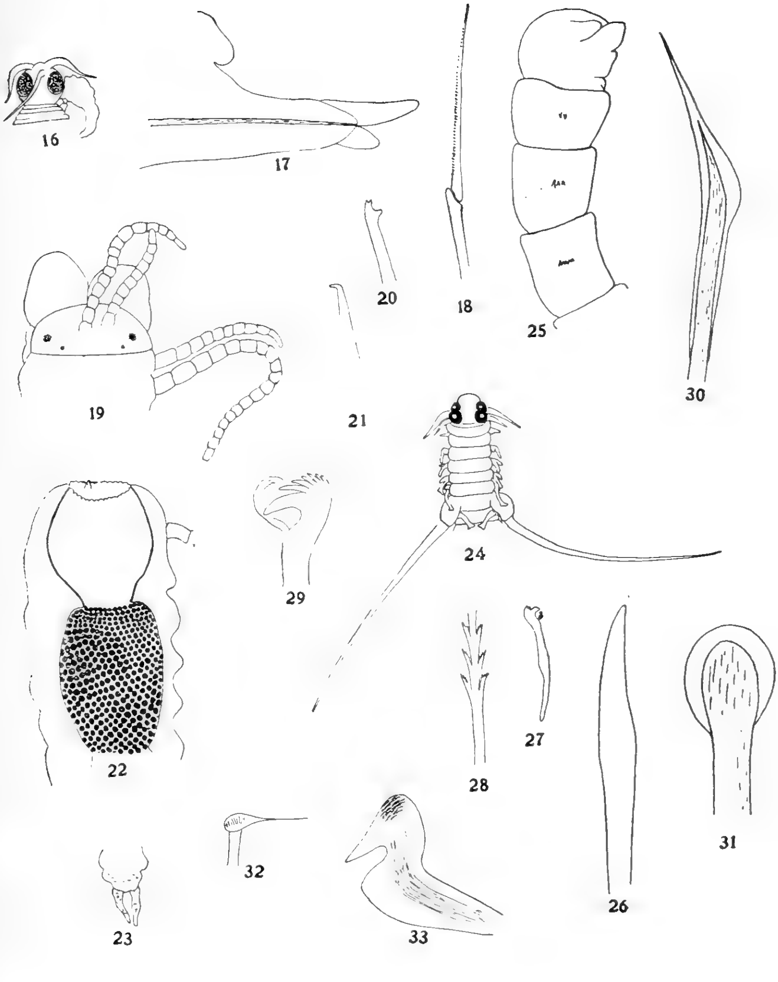
Figures 19 to 23, *Haplosyllis gula* new species. Figure 19, anterior end x 68; figure 20, seta x 250; figure 21, acicula x 250; figure 22, pharynx x 68; figure 23, anal cirri x 68.

Figure 24, Anterior end of *Leptonereis egregicirrata* new species x 8.

Figures 25 to 29, *Nicomache antiguensis* new species. Figure 25, anterior end x 5; figure 26, anterior hook x 45; figure 27, hook from somite 4 x 45; figure 28, seta x 250; figure 29, posterior hook x 185.

Figures 30 to 33, *Hypsicomus purpureus* new species. Figure 30, dorsal thoracic seta x 250; figure 31, second form of dorsal thoracic seta x 250; figure 32, pennoned seta x 250; figure 33, uncinus x 250.

PLATE II



REPORT ON THE FISHES

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

BARTON WARREN EVERMANN

Director of the Museum of the California Academy of Sciences and of the Steinhart Aquarium, and

ALVIN SEALE

Superintendent of the Steinhart Aquarium

The fishes collected in 1918 by the Barbados-Antigua Expedition sent out by the University of Iowa under the direction of Professor C. C. Nutting, were referred to the senior writer of this paper for study and report. A multiplicity of other more pressing duties delayed the fulfillment of this duty until recently.

The collection contains 88 specimens representing 53 species. Although most of the species are common forms, the collection is of considerable interest in establishing new records, in showing what are the more easily obtained species, and the relative abundance of the more common forms.

Following is an annotated list of the species:

1. *Myrichthys oculatus* (Kaup). Snake Eel.

Pisoodonophis oculatus Kaup, Apodes, 22, 1856, Curacao.
Myrichthys oculatus, Jordan & Evermann, Fishes North and Mid. Amer., 376, 1896; Evermann & Marsh, Fishes of Porto Rico, 74, 1902.

One specimen (no. 97), 18.5 inches long, taken July first at Antigua.

Head 4.5; eye 2.5 in snout. No caudal fin; dorsal and anal not continuous; pectoral extremely small. Teeth blunt. Color in alcohol grayish, the side with two rows of large dark spots each with a white center.

2. *Lycodontis moringa* (Cuvier). Common Spotted Moray.

Murœna moringa Cuvier, Règne Animal, ed. 2, vol. 2, 352, 1829 Bahamas.
Lycodontis moringa, Jordan & Evermann, op. cit., 395, 1896; Evermann & Marsh, op. cit., 377, fig. 8, 1902.

One specimen (no. 96), 27.25 inches long, taken July first at Antigua.

Snout 5.75 in head; eye 2 in snout. Two or three long, depressible canines on vomer in front, and a row of small fixed teeth behind.

Color in alcohol dark brown, irregularly mottled with light yellowish; under parts of throat and head with dark spots.

3. *Echidna catenata* (Bloch). Chained Moray.

Gymnothorax catenatus Bloch, Ausl. Fische, 11, 74, pl. 69, figs. 4 and 5, 1738, Brazil.
Echidna catenata, Jordan & Evermann, op. cit., 403, 1896; Evermann & Marsh, op. cit., 79, 1902.

One specimen (no. 95), 18 inches long, taken July first at Antigua.

Head 3; eye 2.5 in snout. Teeth blunt and rounded, in two or three rows on the vomer.

Color in alcohol dark brown reticulated with bright yellow, these markings forming cross-bars on throat and breast.

4. *Cypselurus bahiensis* (Ranzani). Flying Fish.

Exocœtus bahiensis Ranzani, Nov. Comm. Ac. Sci. Inst. Bonon., V, 1842, 362, pl. 38, Bahia; Jordan & Evermann, op. cit., 739, 1896.
Cypselurus bahiensis, Evermann & Marsh, op. cit., 104, 1902.

Two specimens (nos. 98 and 99) 9.2 and 10.2 inches long, taken July first at Barbados.

Head 4; depth 5; eye 3 in head; snout 3.75; interorbital 2.75; D. 10; A. 9. Base of anal 1.75 in base of dorsal; origin of anal under third dorsal ray scales about 57 in lateral series. Some fine teeth on upper jaw. Pectorals long, reaching to caudal peduncle, slightly beyond tips of ventrals.

5. *Mugil curema* Cuvier & Valenciennes. White Mullet; Liza.

Mugil curema Cuvier & Valenciennes, Hist. Nat. Poiss., XI, 87, 1836, Brazil, Martinique, Cuba; Jordan & Evermann, op. cit., 813, fig. 344, 1896; Evermann & Marsh, op. cit., 113, fig. 24, 1902.

One specimen (no. 107), 9 inches long, taken May 14, at Barbados.

Head 4; depth 3.9; eye 4 in head; D. IV-I, 8; A. 111.9; scales 37.

Color in alcohol brownish; tip of caudal, soft dorsal and axil of pectoral dark.

6. *Myripristis jacobus* Cuv. & Val. Candil.

Myripristis jacobus Cuv. & Val., Hist. Nat. Poiss., III, 162, 1829, Martinique; Jordan & Evermann, op. cit., 846.

One specimen (no. 126), 7.75 inches long, taken May 14, at Barbados.

Head 3; depth 2.4; eye 2.1; scales 34; D. X-I, 14; A. IV, 13.

Color in alcohol dull yellowish, slightly darker above; a dark area at posterior edge of opercle to base of pectoral.

7. *Holocentrus ascensionis* (Osbeck). Squirrel Fish; Candil.

Perca ascensionis Osbeck, Iter Chinensis, 388, 1771, Ascension Island.

Holocentrus ascensionis, Jordan & Evermann, op. cit., 848, pl. 131, fig. 358; Evermann & Marsh, op. cit., 118, colored plate 3.

Two specimens (nos. 123 and 124), each about 9 inches long, taken May 14, at Barbados.

Head 3.8; depth 3.4; eye 2.7; snout 1.3 in eye; scales 4.8; D. XI, 15; A. IV, 10. Length of second anal spine more than half depth of body; anterior rays of soft dorsal and caudal rays prolonged, tip of dorsal reaching anterior third of caudal.

Color in alcohol uniform dull yellowish.

8. *Upeneus martinicus* Cuv. & Val. Yellow Goatfish.

Upeneus martinicus Cuv. & Val., Hist. Nat. Poiss., III, 483, 1829, Martinique; Jordan & Evermann, op. cit., 859; Evermann & Marsh, op. cit., 121, colored plate 5.

One specimen (no. 105), 8.5 inches long, taken May 14, at Barbados.

Head 3.3; depth 4; eye 3.2; D. VIII, 18; A. II, 6; scales 37. Teeth biserial in front in each jaw.

Color in alcohol uniform dull yellowish.

9. *Trachurops crumenophthalmus* (Bloch). Big-eyed Scad.

Scomber crumenophthalmus Bloch, Ichth., pl. 343, 1793, Acara in Guinea.

Trachurops crumenophthalmus, Jordan & Evermann, op. cit., 911, pl. 141, fig. 385; Evermann & Marsh, op. cit., 129, fig. 30.

Three specimens (nos. 100, 101, and 102), 6 to 8.25 inches long, taken May 14, at Barbados.

Head 3.1; depth 3.9; eye 2.2. Adipose eyelid fore and aft, covering all but the pupil and middle of the eye; no finlets; lateral line complete and armed with about 40 bony scutes at posterior third; small teeth in jaws in single series, three distinct patches of teeth on vomer, small teeth also on palatines and tongue. Premaxillaries protractile.

Color in alcohol dull yellowish.

10. *Caranx ruber* (Bloch). Carbonero.

Scomber ruber Bloch, Ichth., pl. 342, 1793, St. Croix.
Caranx ruber, Jordan & Evermann, op. cit., 919; Evermann & Marsh, op. cit., 130.

Two specimens (nos. 103 and 104), each about 8.7 inches long, taken May 14, at Barbados.

Head 3.2; depth 3; eye 4.3; snout 2.8; maxillary 2.7; D. VIII-I, 27; A. II-I, 24. No finlets; no fleshy projection from shoulder-girdle into gill-chamber; maxillary protractile; two or more rows of small sharp teeth in jaws, with 2 to 4 large canines anteriorly in each jaw; bands of small teeth on vomer, palatines, and tongue; 35 armed scutes on caudal peduncle.

11. *Caranx latus* Agassiz. Jurel; Horse-eye Jack.

Caranx latus Agassiz, Pisc. Brasil., 106, 1829, Brazil; Jordan & Evermann, op. cit., 923, pl. 142, fig. 389; Evermann & Marsh, op. cit., 132.

One specimen (no. 106), 15.5 inches long taken May 14, at Barbados.

Head 3.1; depth 2.5; eye 4; D. VIII-I, 21; A. II-I, 17; scales 36; maxillary 2 in head. Breast scaled; two series of teeth in jaws, the outer wide-spaced canines.

12. *Bodianus ruber* (Bloch & Schneider). Fino.

Gymnocephalus ruber Bloch & Schneider, Syst. Ichth., 346, pl. 67, 1801, Brazil.
Bodianus fulvus ruber, Jordan & Evermann, op. cit., 1145.
Bodianus ruber, Evermann & Marsh, op. cit., 150.

One specimen (no. 143), 10.5 inches long, taken May 24, at Barbados.

Head 2; depth 2.8; eye 3; snout 4; maxillary 2; D. IX, 15; A. III, 9; scales about 100. Teeth on jaws, vomer and palatines, those on jaws depressible. Caudal truncate.

Color in alcohol dull yellowish, with numerous rows of black dots; two black spots on top of caudal peduncle, and two at tip of lower jaw.

13. *Bodianus punctatus* (Linnæus). Nigger-fish.

Perca punctata Linnæus, Syst. Nat., ed. X, 291, 1758, Bahamas.

Bodianus fulvus punctatus, Jordan & Evermann, op. cit., 1146, pl. 182, fig. 481.

Bodianus punctatus, Evermann & Marsh, op. cit., 150, fig. 43.

Two specimens (nos. 146 and 147), 8 to 9 inches long, taken May 14, at Barbados.

Head 2.7; depth 2.8; eye 6; D. IX, 15, A. III, 9. Front of jaws with hinged teeth; bands of teeth on vomer and palatines. Caudal rounded. Gillrakers 9 on lower limb.

In alcohol numerous small brown spots on body and fins, these largest on head where they have light centers and dark rings.

14. *Epinephelus adscensionis* (Osbeck). Rock Hind.

Trachinus adscensionis Osbeck, Iter Chinensis, 1757, Ascension Island.

Epinephelus adscensionis, Jordan & Evermann, op. cit., 1152, pl. 182, fig. 482; Evermann & Marsh op. cit., 152, colored plate 77.

One specimen (no. 145), 10 inches long, taken May 14, at Barbados.

Head 2.5; depth 3; eye 5; D. XL, 17; A. III, 8; scales 100; gillrakers 18. Jaws with depressible teeth; vomer and palatines with teeth. Caudal rounded. Color in alcohol everywhere with round brown spots about the size of pupil or larger; about 5 more or less indistinct dark bars over the back, the posterior one on the caudal peduncle; fins spotted like the body.

15. *Epinephelus guttatus* (Linnæus). Red Hind.

Perca guttata Linnæus, Syst. Nat., ed. X, 292, 1758, Brazil.

Epinephelus maculosus, Jordan & Evermann, op. cit., 1158 and 3197.

Epinephelus guttatus, Evermann & Marsh, op. cit., 153, colored plate 13.

One specimen (no. 144), 8.7 inches long, taken May 14, at Barbados.

Head 2.5; depth 2.7; D. XI, 16; A. III, 8; about 51 pores in lateral line. Teeth in jaws, vomer and palatines. Caudal rounded.

Color in alcohol dull brown with round brown spots over body, belly and fins; soft dorsal, anal and caudal tipped with black.

16. *Mycteroperca bowersi* Evermann & Marsh. Gray Grouper.

Mycteroperca bowersi Evermann & Marsh, op. cit., 158, Culebra Island, near Porto Rico.

One specimen (no. 142), 14 inches long, taken May 14, at Barbados.

Head 3; depth 2.9; eye 6 in head, 1.5 in snout; gillrakers 15 on lower limb; D. XI, 16; A. III, 12; about 100 pores in lateral line, 134 scales. Teeth on vomer in a narrow V-shaped patch, those on palatines in a narrow line; those on jaws depressible. Maxillary 2 in head, reaching posterior line of pupil; lower jaw projecting; caudal truncate.

Color in alcohol dull brown.

17. *Mycteroperca microlepis* (Goode & Bean). Gag.

Trisotropis microlepis Goode & Bean. Proc. U. S. Nat. Mus., II, 1879, 141, West Florida.

Mycteroperca microlepis, Jordan & Evermann, op. cit., 1177, pl. 188, fig. 494.

One specimen (no. 148), 9 inches long, taken May 14, at Barbados.

Head 2.9; depth 3; eye 5, slightly exceeding interorbital width; D. XI, 18; A. III, 77; scales 150; gillrakers 12 on lower limb. Supplemental bone present. Caudal lunate.

Color in alcohol dull brown.

18. *Hypoplectrus unicolor* (Walbaum). Vaca; Petit-Nègre.

Perca unicolor Walbaum, Artedi Piscium, III, 352, 1792.

Hypoplectrus unicolor, Jordan & Evermann, op. cit., 1190.

One specimen (no. 138), 5.5 inches long, taken May 18, at Barbados.

Head 2.7; depth 2; eye 4; D. X, 15; A. III, 7; lateral line 53 pores, about 70 scales. Small teeth in jaws and a small patch on head of vomer, none on palatines or tongue; opercle with two flat spines; preopercle strongly denticulate, its lower teeth directed forward; 12 developed gillrakers on lower limb; maxillary 2 in head, reaching eye.

Color in alcohol, posterior third jet black; head and fins yellow; a deep black stripe in front of eye.

19. *Paranthias furcifer* (Cuv. & Val.). Creole Fish.

Serranus furcifer Cuv. & Val., Hist. Nat. Poiss., II, 264, 1828, Brazil.

Paranthias furcifer, Jordan & Evermann, op. cit., 1221, pl. 192, fig. 504.

Two specimens (nos. 150 and 151), each about 8 inches long, taken May 14, at Barbados.

Head 3.3; depth 3.2; eye 4; interorbital 3.2; D. IX, 18; A. III, 9; scales 90. Teeth in jaws, vomer and palatines; gillrakers 25 on lower limb; opercular spines 3; preopercle toothed; caudal deeply forked. Color in alcohol brown, darker on back.

20. *Priacanthus cruentatus* (Lacépède). Catalufa.

Labrus cruentatus Lacépède, Hist. Nat. Poiss., III, 522, 1800, Martinique.

Priacanthus cruentatus, Jordan & Evermann, op. cit., 1238; Evermann & Marsh, op. cit., 167.

Two specimens (nos. 127 and 128), 6 and 6.75 inches long, taken May 14, at Barbados.

Head 3; depth 2.5; eye 2.2; maxillary 2, reaching pupil; D. X, 13; A. III, 14; scales about 90. Preopercular spine well developed.

Color in alcohol light yellowish, with about 11 rather distinct band-like stripes over the back.

21. *Rypticus bistrispinus* (Mitchill). Soapfish.

Bodianus bistrispinus Mitchill, Am. Month. Mag. and Crit. Rev., II, February, 1818, 247, Bahama Straits.

Rypticus bistrispinus, Jordan & Evermann, op. cit., 1233, pl. 194, fig. 509; Evermann & Marsh, op. cit., 163, fig. 46.

One specimen (no. 149), 9 inches long, taken May 14, at Barbados.

Head 3, depth 2.9; eye 5.7, slightly less than snout; D. III, 25; A. 15. Preopercle with 3 spines. Teeth in jaws, vomer and palatines; scales small; opercle with 3 flat spines. Head small and pointed, lower jaw projecting.

Color in alcohol uniform brown, tips of fins darker.

22. *Neomænis apodus* (Walbaum). Schoolmaster.

Perca apoda Walbaum in Artedis Piscium, 351, 1792, Bahamas.

Neomænis apodus, Jordan & Evermann, op. cit., 1258, pl. 147, fig. 515; Evermann & Marsh, op. cit., 172, colored plate 19.

One specimen (no. 140), 13 inches long, taken May 21, at Barbados.

Head 2.5; depth 2.9; eye 5.7; D. X, 15; A. III, 8; scales 42; gillrakers 8. Four large canines in front in upper jaw; vomer and palatines with teeth. No notch on preopercle, but the knob well developed.

Color in alcohol dull light brown with indications of 4 or 5 narrow light lines over back.

23. *Neomænis mahogoni* (Cuv. & Val.). Mahogany Snapper.

Mesoprion mahogoni Cuv. & Val., op. cit., II, 447, 1828, Martinique.

Neomænis mahogoni, Jordan & Evermann, op. cit., 1272; Evermann & Marsh; op. cit., 179.

One specimen (no. 139), 12 inches long, taken May 25, at Barbados.

Head 2.5; depth 2.9; D. X, 12; A. III, 8; eye 4; snout 2.75; scales 50; gillrakers 8 below arch; a shallow but wide notch in preopercle, but no knob. Teeth on vomer in a diamond-shaped patch with an extension posteriorly.

Color in alcohol dull yellowish brown, no distinct markings.

24. *Ocyurus chrysurus* (Bloch). Yellowtail; Rabirubia.

Sparus chrysurus Bloch, Ichth., pl. 262, 1700, Brazil.

Ocyurus chrysurus, Jordan & Evermann, op. cit. 1275, pl. 199, fig. 520; Evermann & Marsh, op. cit., 180, colored plate 23.

One specimen (no. 152), 8.7 inches long, collected May 14, at Barbados.

Head 2.9; depth 3; eye 5, slightly greater than interorbital; scales 63. Teeth on jaws, vomer and palatines, none on tongue. Caudal deeply forked.

Color in alcohol dull yellowish brown; an indistinct dark stripe from snout through eye to caudal.

25. *Hæmulon carbonarium Poey.* Ronco Carbonero; Black Grunt.

Haemulon carbonarium Poey, Memorias, II, 176, 1860, Cuba; Jordan & Evermann, op. cit., 1300; Evermann & Marsh, op. cit., 188.

One specimen (no. 141), 7.5 inches long, taken May 21, at Barbados.

Head 2.9; depth 2.5; eye 3.5; D. XII, 14; A. III, 8; scales 53. Bands of villiform teeth in jaws, none on vomer or palatines.

Color in alcohol grayish.

26. *Hæmulon flavolineatum* (Desmarest). French Grunt.

Diabasis flavolineatum, Desmeret, Prem. Decade Ichth., pl. 35, fig. 2, 1823, Cuba.

Haemulon flavolineatum, Jordan & Evermann, op. cit., 1306, 1898; Everman & Marsh, op. cit., 191.

One specimen (no. 153), 8 inches long, without locality or date, taken in fish pot.

Head 3; depth 2.6; eye 3.7; interorbital 3; D. XII, 15; A. III, 9; scales 49. Teeth in irregular rows in jaws, vomer and palatines; scales enlarged above pectorals.

Color in alcohol dull yellowish, with about 16 indistinct oblique stripes on body, following lines of scales above and below lateral line.

27. *Hæmulon plumieri* (Lacépède). Common Grunt.

Labrus plumieri Lacépède, Hist. Nat. Poiss., III, 480, pl. 2, fig. 2, 1802, Martinique.

Hæmulon plumieri, Jordan & Evermann, op. cit., 1304, pl. 205, fig. 532; Evermann & Marsh, op. cit., 190, fig. 54.

Two specimens (nos. 136 and 137), each about 11 inches long, taken July 1, at Barbados in fish pot.

Head 2.7; depth 2.5; eye 5; D. XII, 16; A. III, 8; scales 5-50-7.

Color in alcohol dull grayish brown, head covered with numerous more or less undulating alternating light and dark lines, which extend upward and backward; fins unmarked.

28. *Microspathodon chrysurus* (Cuv. & Val.).

Glyphidodon chrysurus Cuv. & Val., op. cit., V, 476, 1830, St. Thomas.

Microspathodon chrysurus, Jordan & Evermann, op. cit., 1567, pl. 235, fig. 593.

One specimen (no. 88), 5.75 inches long, taken May 24, at Barbados.

Head 2.8; depth 1.8; eye 3.3; snout 2.4; scales 30-21 with pores; D. XII, 14; A. 12. A single series of movable teeth with smooth cutting edge in each jaw, those in lower the larger; preorbital wide, with a notch below nostril.

Color in alcohol uniform dark brown, the caudal yellowish.

29. *Sparisoma aurofrenatum* (Cuv. & Val.). Gold-bridled Parrot-fish.

Scarus aurofrenatus Cuv. & Val., op. cit., XIV, 191, 1839, Santo Domingo.

Sparisoma aurofrenatum, Jordan & Evermann, op. cit., 1634, pl. 243, fig. 610; Evermann & Marsh, op. cit., 238.

Three specimens (nos. 109, 110 and 111), 7.5 to 8.1 inches long, taken May 24 in fish pot at Barbados.

Head 3; depth 2.95; eye 4; D. IX, 10; A. II, 9; scales 24.

Color in alcohol brownish above, lighter on sides and below; a dark spot on sixth scale of lateral line; tip of caudal and axil of pectoral dark; a light stripe with dark margin from corner of mouth to below eye.

30. *Sparisoma lorito* Jordan & Swain. Loro; Parrot-fish.

Sparisoma lorito Jordan & Swain, Proc. U. S. Nat. Mus., VII, 1884, 95, Havana; Jordan & Evermann, op. cit., 1637; Evermann & Marsh, op. cit., 240.

One specimen (no. 115) 10.5 inches long, taken May 24, at Barbados.

Head 3.4; depth 3; eye 6.5; D. IX, 10; A. II, 9; scales 25. One posterior canine. Caudal lunate.

Color in alcohol uniform greenish; a distinct black spot at base of pectoral; outer rays of caudal darker than middle ones.

31. *Sparisoma flavescens* (Bloch & Schneider). Mud Parrot-fish.

Scarus flavescens Bloch & Schneider, Syst. Ichth., 290, 1801, Cuba.

Sparisoma flavescens, Jordan & Evermann, op. cit., 1639; Evermann & Marsh, op. cit., 240.

Three specimens (nos. 112, 113 and 114), each 6 to 7 inches long, taken May 14, at Barbados.

Head 3; depth 2.9; eye 4.8; D. IX, 10; A. II, 9. Four or five large scales on cheek; no posterior canines.

Color in alcohol dark olive brown above, lighter below; a dark area at upper base of pectoral but not extending into axil of fin; fins all yellowish.

32. *Scarus croicensis* Bloch.

Scarus croicensis Bloch, Ichth., pl. 221, 1790, St. Croix; Jordan & Evermann, op. cit., 1650; Evermann & Marsh, op. cit., 244.

One specimen (no. 108), 8 inches long, taken May 21, at Barbados.

Head 3; depth 3.2; eye 6; D. IX, 10; A. II, 9; scales 25.

Color in alcohol brownish above, lighter below; a distinct brown stripe from snout through eye to caudal, and another below this from axil of pectoral to caudal; outer rays of caudal brownish.

33. *Scarus vetula* Bloch & Schneider. Oldwife; Vieja.

Scarus vetula Bloch & Schneider, Syst. Ichth., 289, 1801, Cuba; Jordan & Evermann, op. cit., 1649; Evermann & Marsh, op. cit., 243, colored plate 31.

One specimen (no. 116), 9.2 inches long, without data.

Head 3; depth 3; eye 5.7; D. IX, 10; A. II, 9; scales 25; 2 posterior canines; 4 rows of scales on cheek.

Color in alcohol yellowish green above, lighter below, fins with submarginal lighter bands.

34. *Chætodon capistratus* Linnæus. Mariposa.

Chætodon capistratus Linnæus, Syst. Nat., ed. X, 275, 1758, Indies; Jordan & Evermann, op. cit., 1677; Evermann & Marsh, op. cit., 249, colored plate 35.

One specimen (no. 84), 4 inches long, taken May 14, at Barbados.

Head 3.5; depth 1.5; eye 3.1, scarcely equal to interorbital width; D. XIII, 19; A. III, 17; scales 42.

Color in alcohol yellowish with narrow black lines running obliquely upward and backward above, downward and backward below; a distinct ocular band from lower edge of opercle through eye to origin of dorsal; a black spot larger than eye in front of base of caudal peduncle; a dark intermarginal stripe on soft dorsal, anal and caudal.

35. *Chætodon striatus* Linnæus. Butterfly-fish.

Chætodon striatus Linnæus, Syst. Nat., ed. X, 275, 1758, West Indies; Jordan & Evermann, op. cit., 1677; Evermann & Marsh, op. cit., 249, colored plate 34.

Two specimens (nos. 81 and 82), 4 to 5 inches long, taken May 14, at Barbados.

Head 3.1; depth 1.5; eye 3, equal to interorbital width; snout 2.5; D. VII, 21; A. III, 7; scales 40.

Color in alcohol yellowish, with a jet black band wider than pupil from lower edge of opercle through eye to front of spinous dorsal; a second much wider band from 2d to 5th dorsal spines across side under base of pectoral to belly; a third of slightly greater width from base of last four dorsal spines across side and extending on to soft anal; and a fourth of similar character from soft dorsal across caudal peduncle on to base of anal; a diffuse darker spot in this band below soft dorsal, and one on caudal peduncle; ventrals black.

36. *Holacanthus tricolor* (Bloch). Rock Beauty.

Chætodon tricolor Bloch, Ichth., pl. 426, 1795, Cuba.

Holacanthus tricolor, Jordan & Evermann, op. cit., 1684; Evermann & Marsh, op. cit., 251, colored plate 36.

Two specimens (nos. 85 and 86), each about 5 inches long, taken May 14, at Barbados.

A strikingly beautiful fish. In life the anterior fourth is rich orange as is also the tail and the posterior edges of the soft dorsal and anal; middle part of body jet black; a red border to dorsal and anal fins; pectorals and ventrals yellow or orange; edge of opercle and preopercle red. These colors all fade in spirits.

37. *Chætodon ocellatus* Bloch. Butterfly-fish.

Chætodon ocellatus Bloch, Ichth., pl. 211, fig. 2, 1787; Jordan & Evermann, op. cit., 1674.

Chætodon striatus, Evermann & Marsh, op. cit., 249, colored plate 34.

One specimen (no. 83), 5 inches long, taken May 14, at Barbados.

Head 3; depth 1.5; eye 3; interorbital 2.8; snout 2.5; D. XII, 21; A. III, 18; scales 40.

Color in alcohol dull yellowish, a black ocular band width of pupil from near origin of dorsal through eye to lower edge of opercle a black spot size of eye on middle base of soft dorsal.

38. *Angelichthys ciliaris* (Linnæus). Blue Angel-fish; Isabelita.

Chætodon ciliaris, Linnæus, Syst. Nat., ed. X, 276, Indies.

Angelichthys ciliaris, Jordan & Evermann, op. cit., 1684, pl. 254; Evermann & Marsh, op. cit., 252, colored plate 37.

One specimen (no. 87), 7.25 inches long, taken in fish pot May 28, at Barbados.

Head 3.5; depth 1.7; eye 4.25 in head, 1.5 in interorbital width; snout 2.1; D. XIV, 20; A. III, 21.

Color in alcohol dull brown or drab; a black ocellus with a dark blue rim just in front of spinous dorsal; dorsal and anal edged with deep blue.

39. *Hepatus cæruleus* (Bloch & Schneider). Blue Tang.

Acanthurus cæruleus Bloch & Schneider, Syst. Ichth., 24, 1801, Carolina.

Teuthis cæruleus, Jordan & Evermann, op. cit., 1691; Evermann & Marsh, op. cit., 253, colored plate 38.

Three specimens (nos. 129, 130, and 131), 4 to 6 inches long, taken in fish pots May 14 and 31, at Barbados.

Head 3.5; depth 1.7; eye 2.5 in snout; D. IX, 26; A. III, 25.

Color in alcohol brown with indistinct narrow longtitudinal stripes on side; vertical fins dark; pectoral yellow.

40. *Hepatus hepatus* (Linnæus). Common Barbero; Tang.

Teuthis hepatus Linnæus, Syst. Nat., ed. 12, 507, 1766, Carolina; Jordan & Evermann, op. cit., 1691; Evermann & Marsh, op. cit., 254.

One specimen (no. 134), 6 inches long, taken June 14, at Barbados.

Head 3.7; depth 2; eye 2.1; D. IX, 25; A. III, 25.

Agrees only fairly well in color with typical *hepatus;* the distal portion of pectoral apparently yellow.

41. *Hepatus bahianus* (Castelnau). Ocean Tang; Medico.

Acanthurus bahianus Castelnau, Anim. Nouv. ou Rares de l'Amer. Sud, 24, pl. 11, fig. 1, 1855, Bahia.

Teuthis bahianus, Jordan & Evermann, op. cit., 1693, pl. 256, fig. 629; Evermann & Marsh, op. cit., 254.

Three specimens (nos. 132, 133 and 135), 6 to 8 inches long, taken May 14, at Barbados.

Head 3.7; depth 22; eye 3; D. IX, 25; A. III, 23.

This is the common ocean tang or surgeon-fish of the West Indies. It attains a larger size than any other tang of the region.

42. *Melichthys piceus* (Poey). Blue Trigger-fish.

Balistes piceus Poey, Proc. Acad. Nat. Sci. Phila. 1863, 180, Cuba.
Melichthys piceus, Jordan & Evermann, op. cit., 1711.

One specimen (no. 79), 6.5 inches long, taken May 17, at Barbados.

Head 3.2; depth 1.9; eye 3.1 in snout; D. II-I, 34; A. 31; scales 54; first dorsal spine 1.8 in head, the third almost obsolete. Teeth even; scales on posterior part of body keeled; several larger scales behind gill-opening; a groove in front of eye; no lateral line.

Color in alcohol uniform black with a narrow white line along base of dorsal and anal.

43. *Cantherines pullus* (Ranzani). Lija Colorada; Tile-fish.

Monacanthus pullus Ranzani, Nov. Com. Act. Sci. Inst. Bonon., V, 4, pl. 1, 1842, Brazil.
Cantherines pullus, Jordan & Evermann, op. cit., 1713; Evermann & Marsh, op. cit., 258.

One specimen (no. 93), 6.25 inches long, taken May 14, at Barbados.

Head 3.9; depth 2; eye 3.25; D. II, 35; A. 31. First dorsal spine equal to snout, above front of eye.

Color in alcohol dull grayish, fins lighter.

44. *Alutera scripta* (Osbeck). Unicorn Filefish.

Balistes scriptus Osbeck, Iter Chinensis, I, 144, 1757, China.
Alutera scripta, Jordan & Evermann, op. cit., 1719, pl. 260, fig. 637; Evermann & Marsh, op. cit., 261, fig. 73.

One specimen (no. 80), 19.75 inches long, taken June 4, at Barbados.

Head 3.7; depth 2.5; eye 5.4; D. I, 47; A. 50.

Color in alcohol dull drab, with some darker marblings.

45. *Lactophrys triqueter* (Linnæus). Trunk-fish; Chapin.

Ostracion triqueter Linnæus, Syst. Nat., ed. 10, 330, 1758, India.
Lactophrys triqueter, Jordan & Evermann, op. cit., 1722, pl. 261, fig. 638; Evermann & Marsh, op. cit., 262, fig. 74.

Three specimens (nos. 118, 119, and 120), 5 to 6 inches long, collected May 14, at Barbados.

Head 3.75; depth 2; eye 2.2 in snout, less than interorbital width; D. 10; A. 10.

Carapace trigonal, without spines.

Color in alcohol dull greenish, darker at base of pectoral, dorsal and tip of caudal.

46. *Lactophrys tricornis* (Linnæus). Common Trunk-fish; Cowfish.

Ostracion tricornis Linnæus, Syst. Nat., ed. 10, 331, 1758.
Lactophrys tricornis, Jordan & Evermann, op. cit., 1724, pl. 261, fig. 639; Evermann & Marsh, op. cit., 264, fig. 77.

One specimen (no. 117), 9 inches long, obtained May 14, at Barbados.

Head 4.2; depth 2.4; eye 2.1 in snout, somewhat less than interorbital width; D. 10; A. 10. Carapace trigonal, the angles carinate, a stout spine directed forward over each eye; an abdominal spine on each side directed backward.

47. *Spheroides testudineus* (Linnæus). Globe-fish; Tamboril.

Tetraodon testudineus Linnæus, Syst. Nat., ed. 10, 332, 1758.
Spheroides testudineus, Jordan & Evermann, op. cit., 1734, pl. 265, figs. 646 and 646a; Evermann & Marsh, op. cit., 269, colored plate 41.

One specimen (no. 122), 8 inches long, taken May 15, at Antigua.

Head 3; depth 2 in head; interorbital width 3.2 in head, 1.75 in snout; D. 8; A. 6. Central part of body with prickles.

48. *Chilomycterus antennatus* (Cuvier). Spiny Puffer.

Diodon antennatus Cuvier, Mém. Mus., IV, 131, pl. 7, 1818.
Chilomycterus antennatus, Jordan & Evermann, op. cit., 1750; Evermann & Marsh, op. cit., 272, colored plate 42.

One specimen (no. 121), 6 inches long, taken May 4, at Barbados.

Body covered with short, strong spines, two above the orbits and one on the middle of the forehead. D. 13; A. 10.

49. *Balistes vetula* Linnæus. Oldwife; Cochino.

Balistes vetula Linnæus, Syst. Nat., ed. 10, 329, 1758, Ascension Island; Jordan & Evermann, op. cit., 1703; Evermann & Marsh, op. cit., 256, colored plate 39.

One specimen (no. 78), 18 inches long (without filaments), taken May 24, at Carlisle Bay, Barbados.

Head 3; depth 1.9; eye 4.25; D. III, 29; A. 27. No spines on side of tail, the scales smooth; lobes of caudal and anterior dorsal rays prolonged in filaments; scales on sides of belly largest.

Color in alcohol brownish green; a few narrow lines of blue radiate from eye; two wide blue lines on cheek.

50. *Scorpæna nuttingi* Evermann & Seale, new species.
Plate I.

Head in length 2.33; depth 3; eye in head 5.5; snout 3.5; interorbital width 5; maxilary 2; mandible 2.1; preorbital 3.5; D. XII, 10; A. III, 5; scales in lateral line about 42, with about 24 pores. Maxillary reaching vertical or posterior edge of pupil.

Suborbital stay with 3 distinct stout spines; 3 short stout orbital spines; a similar spine at each corner of the occipital pit, each of the posterior pair double; preopercle with 4 spines, the upper one with a superimposed spine; opercle with 2 long, flat spines and a smaller one above. A deep pit between suborbital stay and anterior part of orbit; interorbital area deeply concave; occiput with a deep quadrate pit, with a short stout spine at each corner. Breast sparsely scaled; no scales on top of head; about 4 rows of thin scales on cheek behind eye; numerous dermal flaps on head, particularly on lower jaw; numerous flaps on body, largest along lateral line; no supraocular flap.

Fins all strong; fourth dorsal spine longest, about 2.75 in head; second anal spine strong, longer than third, about 2 in head; pectoral large, its length a little less than that of head, the lower 11 rays and the upper 5 unbranched, the middle 3 branched.

Color in alcohol, a dark area on upper part of side just behind opercular flap and extending on spinous dorsal where it is mottled with white; a large black area on side under soft dorsal and extending on to it; pectoral, ventral, and anal mottled with dark; 3 black bars on caudal, one at base.

This species appears to be related to *Scorpæna plumieri* Bloch, from which it differs chiefly in the entire absence of a supraocular flap, the shorter maxillary, and in having 5 (instead of only one) of the upper rays of the pectoral branched.

The collection contains but one specimen of this species. It was taken May 15 in a fish pot in Carlisle Bay, Barbados.

We take great pleasure in naming this interesting species for Charles Cleveland Nutting, professor of zoology, University of Iowa, and director of the University of Iowa Expedition to Barbados and Antigua in 1918, in recognition of his valuable studies of the aquatic fauna of the West Indies.

The type is in the Museum of the State University of Iowa.

51. *Cephalacanthus volitans* (Linnæus). Flying Robin; Flying Gurnard.

Trigla volitans Linnæus, Syst. Nat., ed. 10, 302, 1758.
Cephalacanthus volitans, Jordan & Evermann, op. cit., 2183, pl. 323, fig. 778; Evermann & Marsh, op. cit., 285, fig. 86.

One specimen (no. 91), 12.75 inches long, obtained June 4, at Barbados.

Head 4; depth 5.7; D. II-IV, 8; A. 6. Pectorals developed into long wing-like structures extending to caudal peduncle; head incased in a bony case; preopercular spine very long.

Color in alcohol greenish, lighter below; pectorals darker; soft dorsal rays with dark spots.

52. *Antennarius multiocellatus* (Cuv. & Val.). Tiger Fishingfrog.

Chironectes multiocellatus Cuv. & Val., Hist. Nat. Poiss., XI, 422, 1837, Martinique.
Antennarius multiocellatus, Jordan & Evermann, op. cit., 2724.

One specimen (no. 90), 4.5 inches long, taken at Barbados.

Anterior dorsal spine terminating in 2 cutaneous flaps or bait, the second spine slightly longer than eye, its origin on line with anterior edge of orbit, the third thick and connected with the dorsal by a wide, thick membrane; no dermal flaps.

Color in alcohol yellowish, with several black spots or ocelli, there being 2 very distinct ones on soft dorsal, 3 on caudal, and others on various parts of body.

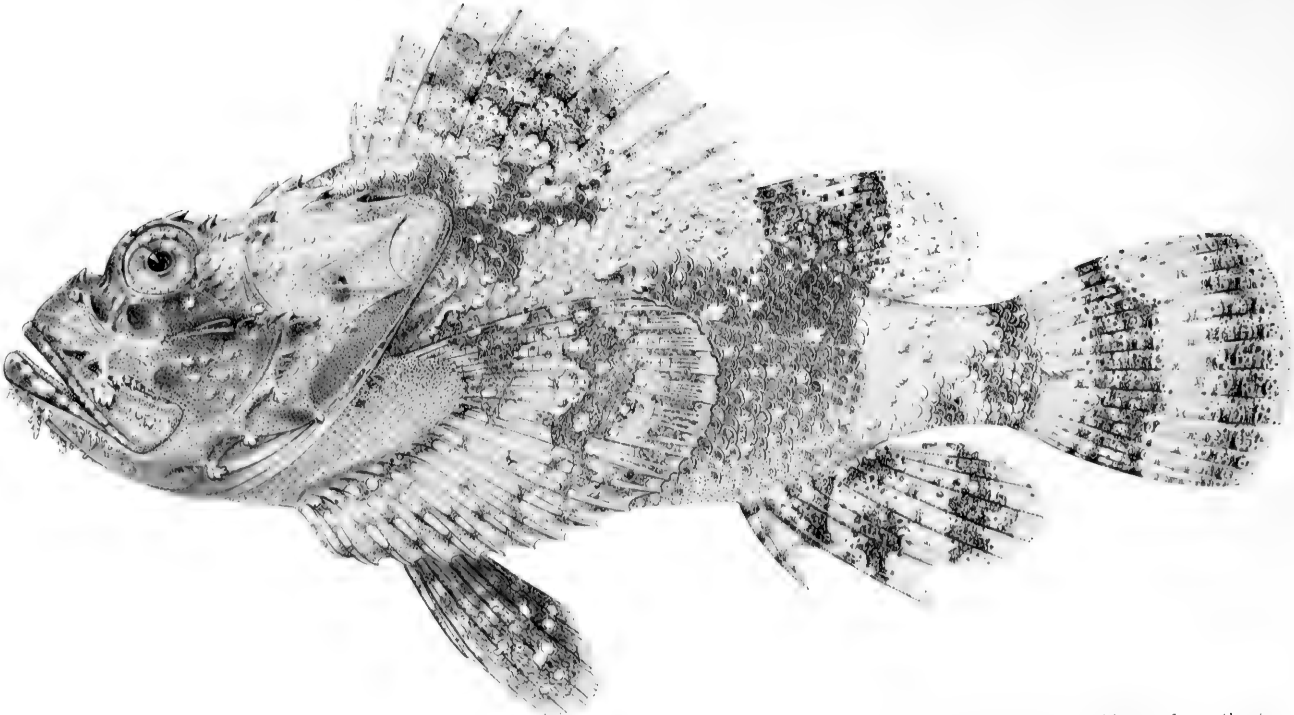
53. *Dibranchus atlanticus* Peters.

Dibranchus atlanticus Peters, Monats. Kon. Akad. Wiss. Berlin, 1876, 736 with plate, West Africa; Jordan & Evermann, op. cit., 2743.

One specimen (no. 89), 10.5 inches long, taken July 4, at Needham Point, Barbados.

Disk somewhat triangular; forehead and snout depressed; snout less than eye; body covered with strong tubercles and short spines; no teeth on vomer or palatines.

Color in alcohol grayish above, lighter below; caudal blackish at tip.



Drawing by W. C. Atkinson from the type

Scorpaena nuttingi Evermann and Seale, new species

REPORT ON THE CHILOPODA AND DIPLOPODA

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

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CHILOPODA

Specimens of two species of chilopods were secured by the Expedition on Barbados Island, one of these being a geophiloid form of the genus *Mecistocephalus,* the other a scolopendroid of the typical genus *Scolopendra.*

Order SCOLOPENDROMORPHA

Family **Scolopendridæ**

Scolopendra subspinipes Leach.

Trans. Linn. Soc. London, XI (1814), p. 383.

Of the seven or eight large centipeds of the genus *Scolopendra* recorded from the West Indies, the present species and *Scolopendra alternans* Leach are much the most common and widespread. *S.alternans* is a characteristically West Indian form and the more abundant generally speaking, while *S.subspinipes* is apparently of oriental origin though now spread over all the warmer regions of the earth excepting about the Mediterranean Sea. It has been recorded previously from Barbados while *S.alternans* has not, and it is possible that the latter, the native species, has been there wholly displaced.

While in the East Indian and adjacent regions *S.subspinipes* presents a number of well-marked varieties, only the *forma typica* is known to occur in the West Indies, and the specimens from Barbados conform fully to it. The species sometimes attains a length of 200 mm.

Six medium and small sized specimens were taken by A. O. Thomas at Speighstown, Barbados, May 19, 1918.

Scolopendra alternans Leach

Trans. Linn. Soc. London, XI (1812), p. 383.

This is a characteristically West Indian species which, in general, is more abundant on the islands than the preceding species. In general appearance the two species are similar and both attain a maximum length of about 200 mm. *S. alternans* may be distinguished from *S. subspinipes* in having numerous spines on the third joint of the anal legs in place of the two larger ventral ones in the latter species; also in having dorsal spines at the end of the third joint of the penult legs where *S. subspinipes* has none.

S. alternans has been recorded from Antigua by Pocock (Jour. Linn. Soc. London, XXIV [1893], p. 458). It has not as yet been noted from Barbados, although it in all probability occurs there.

Order GEOPHILOMORPHA

Family **Mecistocephalidæ**

Mecistocephalus maxillaris (Gervais).

Geophilus maxillaris Gervais, Ann. Sci. Nat., ser. 2, VII (1837), p. 52.

This is also a tropicopolitan species. It is the only member of the genus known from South America and the West Indies. It is probably a more abundant form than records indicate, as it is small, commonly measuring well under 40 mm. in length, and usually is found buried in the earth. It is not infrequently found in the soil about plants imported to the United States from South America, the writer having identified specimens thus taken at quarantine at New York, Philadelphia and Washington, D.C. It has also been found in botanical gardens at Hamburg and Paris, and was first described from a specimen found in the latter locality.

One specimen taken at St. Michaels, near Bridgetown, Barbados, by D. Stoner in May, 1918.

DIPLOPODA

As in the case of the chilopods, very few kinds of diplopods are as yet known to occur on Barbados and Antigua, only four species having been recorded. The diplopod material of the present expedition examined by the writer was all taken on Barbados by Prof. Stoner and represents two of these species, *Orthomorpha coarctata* (Saussure) and *Rhinocricus monilicornis* (Porat). The four species are given below.

Superfamily SPIROBOLOIDEA

Family **Rhinocricidæ**

Rhinocricus monilicornis (Porat)

Spirobolus monilicornis Porat, Bih. Svensk. vet.-akad. Handl., IV, no. 7, (1876), p. 31.

Rhinocricus monilicornis Pocock, Jour. Linn. Soc. London, XXIV (1894), p. 499.

Spirobolus heilprini Dollman, Proc. Acad. Nat. Sci. Phil., (1889), p. 127.

Rhinocricus monilicornis Chamberlin, Bull. Mus. Comp. Zool., LXII, (1918), p. 200; Ann. Ent. Soc. America, XIII, (1920), p. 275.

Eight specimens of this species were taken on Barbados by Prof. Stoner. The form had been previously recorded from this locality by Pocock (as cited above). *R. monilicornis* is also known from Haiti, Trinidad, Tobago and South America as well as from the Bermuda Islands, where it seems to be common.

Rhinocricus arboreus (Saussure)

Julus arboreus Saussure, Linnæa ent., XIII, (1859), p. 331.

Spirobolus (*Rhinocricus*) *arboreus* Karsch, Zeits. naturwiss., (1881), ser. 3, VI, (1881), p. 8.

Rhinocricus arboreus Pocock, Journ. Linn. Soc. London, XXIV, (1894), p. 493, pl. 38, f. 4.

Rhinocricus arboreus Chamberlin, Bull. Mus. Comp. Zool., LXII, (1918), p. 197; Proc. U. S. Nat. Mus., LXI, no. 10, (1922), p. 9.

This large milliped, originally described from St. Thomas Id., is also known from Porto Rico, where it is common, Culebra, St. Croix and Antigua. It has not been recorded from Barbados. Presumably it takes its name from the fact that it is said to ascend trees after the manner of certain large species of the allied genus *Dinematocricus* of the Solomon and Fiji Islands and of the East Indies in general.

Cubobolus politus (Porat)

Spirobolus politus Porat, Ann. Soc. ent. Belg., XXXII, (1888), p. 243.

Rhinocricus politus Pocock, Journ. Linn. Soc. London, XXIV, (1894), p. 488.

This species is known only from the original description, which was based upon specimens from Antigua. In lacking scobina it apparently belongs to the group of species separated by the writer from *Rhinocricus* under the generic name *Cubobolus* (Proc. U.S.N.M., no. 10, LXI [1922] p. 10.)

Superfamily POLYDESMOIDEA

Family **Strongylosomidæ**

Orthomorpha coarctata (Saussure)

Polydesmus coarctatus Saussure, Mem. Myr. Mex., (1860), p. 39, f. 18.

Orthomorpha coarctata Pocock, Ann. Mus. civ. Genoa, ser. 2, XIV, (1895), p. 809.

Orthomorpha coarctata Chamberlin, Bull. Mus. Comp. Zool., LXII, (1918), p. 245.

A number of specimens of this species were taken on Barbados. Although doubtless originating in the East Indian region, the species is now tropicopolitan. It is one of the forms most commonly transported by ship along with plants from tropical countries and is often thus intercepted at quarantine in ports of the United States. It is now well established throughout the West Indies, in Central America, and in other portions of the warmer section of the Western Hemisphere.

THE GENUS HOLOPUS, WITH THE DESCRIPTION OF A HITHERTO UNRECORDED SPECIMEN OF H. RANGII

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

Frank Springer

INTRODUCTION

The island of Barbados is especially associated in the minds of naturalists with the curious crinoid genus *Holopus.* Of the single recent species of this genus only eleven specimens are known, of which certainly six and probably seven (possibly eight) are from Barbados.

In view of the interest attaching to this form, upon which the literature is widely scattered and largely inaccessible to the average student, it has seemed advisable to give here a detailed account of it, reproducing also the more important of the pictures previously published.

In addition to the recent *H. rangii* d'Orbigny (including *H. rawsoni* Gray) the genus may also include *Holopus spileccense* (Schlüter) from the Italian Tertiary, originally described as *Cyathidium,* but afterwards referred to the present genus by Jaekel.[1]

HISTORICAL ACCOUNT

The first known specimen of *Holopus* was obtained in the island of Martinique by M. Sander Rang, who procured it, while it was still alive, from a fisherman. He sent it to Professor Alcide d'Orbigny, and the latter in 1837[2] published a very detailed description, calling it, after its discoverer, *Holopus rangii.* The original account of this extraordinary animal naturally attracted wide attention, and it was reprinted in various French, English and German journals.

D'Orbigny made a section of the column of this specimen,

[1] Zeitschr. d. Deutsch. geol. Gessell. 1891, p. 619.

[2] Magazin de Zoologie, 7me Annee, 1837, Cl. X, pp. 1-8.

and found it to be hollow, the cavity occupying its entire length; he assumed that this cavity contained the viscera. A remarkable feature of this individual was that it possessed only four rays and eight arms; this was recognized by d'Orbigny as a curious anomaly.

After d'Orbigny's death his entire museum was purchased by the Jardin des Plantes (Museum d'Histoire Naturelle), where his specimen of *Holopus* was examined by Sir Wyville Thomson in 1867.

Roemer in Bronn's Lethaea Geognostica, 1856, p. 226 (followed by Bronn in his "Klassen und Ordnungen des Thier-Reichs," published in 1861) proposed a new family, Holopidæ, for the reception of *Holopus*.

In 1862 Dujardin and Hupe, in their "Histoire naturelle des Zoophytes Échinodermes," stated that from the published description and figures of *Holopus* they were strongly inclined to consider it as something quite different from an echinoderm, and suggested that it might be a barnacle; they retained for it the family name Holopidae.

In 1871 Dr. J. E. Gray[3] published the following note from Mr. (later Sir) Rawson W. Rawson, C.B., the Governor of Barbados, together with a figure of a specimen of *Holopus* lacking the bivial arms:

"I have procured a specimen of a Pentacrinus from the north of the island of Barbados, dredged or, rather, picked up, in about 5 fathoms water. It is ink-black, a portion broken so as to show the interior of the contracted armlets and the pentacrinal formation of the mouth or entrance of the central canals. Do you know what it is? I am under the impression of having seen an engraving of such a zoophyte, but cannot find it."

Mr. Rawson added in regard to the local habitat of this form and of the species of *Isocrinus*:

"I believe that they are all procured on the same bank, which, instead of five or six miles from the shore, as I was first informed, cannot be more than a mile, within the hundred fathom line."

Dr. Gray at once recognized the figure as representing a

[3] Ann. and Mag. Nat. Hist., ser. 4, VIII, pp. 394-396, with a figure.

species of d'Orbigny's genus *Holopus,* of which he gives a short history. He says further that—

"there are certain points in which the form of the arm in Mr. Rawson's figure is very unlike that of the species from Martinique which d'Orbigny has called *H. rangii.* I would, therefore, propose to distinguish the Barbados specimen by the name *H. rawsoni,* and hope very shortly to be able to give a more detailed description of this most interesting discovery in crinoidal genera."

In December, 1871, the "Hassler" with Professor Louis Agassiz on board visited Barbados, where she dredged in various depths between 80 and 120 fathoms off Sandy Bay on the western (leeward) coast. In his memoir on the crinoids and corals of the "Hassler" expedition Count Pourtalès says of Barbados that—

"It is a well-known locality for *Pentacrinus asterias* and *mülleri,* and the second specimen of *Holopus rangii* d'Orbigny known to science, in the possession of Governor Rawson of Barbados, was brought up on a fisherman's hook in the same vicinity. We had not the luck to find either of these, though numerous joints of the stem of *Pentacrinus* were contained in the sand."

The specimen of *Holopus rangii* to which he refers is evidently the one from which the figure sent to and published by Dr. Gray was drawn; and the fact that Governor Rawson loaned it to Professor Agassiz for study and description accounts for the non-appearance of Dr. Gray's projected memoir on the genus.

During his last days at the Museum of Comparative Zoology Professor Agassiz was occupied in preparing a paper on Sir Rawson Rawson's specimen of *Holopus* for the zoological results of the "Hassler" expedition. After his death the figures which had been drawn for him by Mr. E. Konopicky were published in 1874, together with a short description of the specimen by Count Pourtalès.[4] This description is as follows:

"The specimen was attached by a broad, incrusting calcareous base, but slightly more expanded than the body, which is

[4] Illustrated Catalogue, Mus. Comp. Zool., No. VIII (1874), p. 51, pl. 10.

thick, inversely conical, bent towards one side, of a hard, semicalcareous substance, having under a magnifier a very delicate shagreen-like appearance. There are no sutures discernible with certainty, though in some parts there appear to be faint indications of them. I did not feel justified in making attempts to render them more apparent by preparation. There are two rows of blunt tubercles on the body part, corresponding to the middle of each arm; a small tuberculated area is also noticeable near the border of the calicle between these rows, and scattering tubercles are found over other parts of the body. Ten arms originate in pairs from five axial joints; the original specimen of d'Orbigny is described as having had but eight, and was certainly anomalous. The axial joints are pentagonal with rounded angles, hemispherically swollen and tuberculated in the middle, closely joined to each other laterally; the tubercles on these joints are in three irregular rows, one in the middle and one corresponding to the middle of each arm. The inside of these joints is deeply channeled in the middle. The arms are composed of thick, short joints, wedge-shaped, swollen and tuberculated; the articulations form a deep transverse furrow. There are no syzygies. When contracted the arms are rolled in a spiral, and pressed laterally against one another so as to enclose a hermetically closed cavity. At the eighth or tenth joint the arm contracts suddenly, and becomes wedge-shaped outside, so as to fit more closely against its neighbors, the rest of the arm being rolled up inside of the cavity. The cirrhi of the arms are formed of broad, flat joints, fitting also closely to their neighbors, and rolled up spirally towards the ambulacral channel of the arm when contracted. The mouth is surrounded by five triangular plates, by which it can be apparently almost or entirely closed. These pieces are deeply and irregularly corrugated on the outside. The intervals of the plates or angles of the mouth correspond to the ambulacral channels. There is a small triangular plate in one of the interambulacral spaces inside of the axial joints, which is probably an anal plate, but no opening can be detected near it. The internal or digestive cavity could not be examined.

"The specimen was obtained at Barbados by a fisherman, who brought it from deep water upon his hook; it has lost four of its arms, but is otherwise complete. It is dry and of black color, somewhat lighter on the arms. The whole specimen in its contracted state is about one inch and three-fourths high."

From a comparison of the figures it seems reasonably certain that the peculiarly distorted specimen described by Pourtalès was the same as that mentioned by Gray for which he suggested the name *Holopus rawsoni.*

At a meeting of the Royal Society of Edinburgh held on June 4, 1877, Professor Sir C. Wyville Thomson discussed the structure and relationships of the genus *Holopus,* basing his remarks upon a specimen loaned him by Sir Rawson W. Rawson.[5]

Sir Wyville states that a second specimen in the collection of Governor Rawson had been lent by him to Professor Louis Agassiz at the time of the visit of the ''Hassler'' to Barbados; and that Professor Agassiz intended to publish a full description of the specimen, but was prevented from so doing by failing health, and after his death the figures which he had prepared were published by his son Alexander Agassiz, with a short note by Court Pourtalès, in the Zoological Results of the ''Hassler'' expedition.

This second specimen is evidently the one of which a figure was published by Gray, who, however, never saw it, and which was described in detail by Pourtalès in connection with the figures by Konopicky. Gray gives the depth of the habitat as 5 fathoms, while Pourtalès says it was brought up from deep water. But Sir Rawson states that while at first he believed it to have come from deep water, he later found that it actually came from shallow water.

Sir Wyville says that during the last few years (preceding 1877) three specimens of *Holopus rangii* had fallen into Sir Rawson Rawson's hands. All were brought up on fishermen's lines from deep water off Barbados. One is very complete in all important parts, wanting only the two bivial arms, but retaining the orals. The second is a little larger; it lacks the orals and the bivial arms. With Sir Rawson's permission he boiled this specimen down in order to figure and describe the separate parts. The third specimen is quite perfect, but very young, only 8 mm. in height.

Besides these three specimens, of which the first is evidently the one mentioned in the letter from Governor Rawson to Dr. Gray and subsequently loaned to Professor Agassiz, Sir Wyville knew of only one other; this was shown at the Philadelphia Exhibition, and was afterwards purchased by the Museum of Comparative Zoology.

Sir Wyville believed that the column, or ''tube-like body

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[5] Proc. Roy. Soc. Edinburgh, IX (1876-77), p. 405.

chamber,'' of *Holopus* was formed of the basals, radials, and probably also the primary brachials fused together. He noticed that the upper portion of the hollow column expands slightly, and its thickened upper border is divided into five well developed facets for the articulation of the five arm pairs, each facet bearing an axillary followed by two arms. These facets, he concluded, represent the upper surfaces of the primibrachs; but, if so, they differ from the primibrachs of all other recent crinoids in being united with the axillaries by a true muscular articulation instead of by an articulation of the non-muscular type. He suggests the alternative that they may be the distal articulating surfaces of the radials, in which case the following segments may be formed of the two primibrachial ossicles coalesced, and the non-muscular articulation between them obliterated; or, he says, there may be only one radial and one primibrach ossicle. He describes the upper border of the cup bearing the facets as being very irregular in thickness, and in all the specimens which he examined, including d'Orbigny's, one side of the border is much thicker, and consequently higher, than the other, and the three arm pairs articulated to it are much larger than those articulated to the opposite side. There is a very marked division into bivium and trivium, and consequently a bilateral symmetry underlies the radial arrangement. The axillaries are each succeeded by two series of about eight similar thick wedge-shaped brachials, very convex externally, and giving off laterally, alternating on either side of the arm, very broad flat pinnules each consisting of about six plate-like segments. The brachials are also provided with strong lateral processes forming a wall on either side of the radial groove, and the sides of adjacent series of these first eight brachials are marked with corresponding grooves and ridges, so that, although from the presence of articulating ridges of varying degrees of obliquity and of muscular impressions the proximal portions of the arms must be capable of some motion, that motion would appear to be slight. After about the eighth the brachials suddenly contract in size and become greatly compressed, and this narrow series extends to about sixteen in number, gradually tapering to the end of the arm. The facets on the edge of the hollow column he describes as follows:

"Each facet is traversed by a transverse articulating ridge, a little in front of which there is the mouth of the tube which lodges the sarcode axis of the ossicles, and a little behind its center there is a somewhat longer aperture which appears to lead into the cancellated structure of the outer part of the wall. There are two large shallow muscular impressions on the surface of the facet on the proximal aspect of the transverse ridge. A vertical mark, sometimes a groove and sometimes a ridge, runs from the center of each articulating facet down the inside of the wall of the hollow column for about two-thirds of the depth of the cavity, where it is lost. At the bases of the arms, just above the edge of the cup, five thick calcareous bosses, each composed of the contiguous lateral processes of two axillaries, project interradially into the cup, and opposite these five rather large triangular plates meeting in the center of the disc, form a low pyramid covering the mouth; these oral plates are inter radial, and the spaces between them radial, corresponding with the arm grooves."

Sir Wyville notes that d'Orbigny describes the animal as possessing no anal opening, and says that this is probably the case, "but the material is still too scanty to admit of the full examination of a complete specimen of the skeleton, and the soft parts are unknown."

Sir Wyville concludes that *Holopus* is especially characterized among living crinoids by the absence of an articulated column, or its representative, the centrodorsal; by the viscera being lodged in a hollow peduncle with a continuously calcified wall; and by the absence of an anal opening. The similarity of *Holopus* and *Cyathidium*, between which types he sees no distinction of generic value, is noted.

In 1878 two figures drawn by J. Henry Blake from preliminary sketches by Alexander Agassiz of a young *Holopus* dredged in 100 fathoms by the "Blake" off Bahia Honda, Cuba, in 23° 01′ N. lat., 83° 14′ W. long., were published, together with a descriptive note by Count Pourtalès.[6]

Pourtalès says:

"The specimen is attached to a piece of rock, and was not detected until it had become dry. The general shape is a truncated cone when contracted, with irregular contour of attachment. The body part is very short, spreading out a little at the foot; surface granulated or shagreen-like, with a few small

[6] Bull. Mus. Comp. Zool., V (1878), p. 213.

tubercles scattered over it. No trace of divisions can be detected in this part. Above, there are two circles of five plates each, fitting closely together and concealing the arms entirely. The lower plates are pentagonal with rounded corners, the upper and lower sides being parallel. The lower sides do not form a continuous line from plate to plate, so that there are small triangular spaces left between them. There is a row of tubercles on each side of a plate, and one in the middle forming a ridge which projects a little downward over the lower edge of the plate. On the upper edge of these plates are articulated five smaller triangular ones, firmly closed together. They have also a ridge in the middle in continuation of the ridge in the lower plates. The larger pentagonal plates are the radial axillaries of Sir Wyville Thomson, but the smaller triangular ones seem to become fused with them in the adult. Color black. Diameter at base 3 mm.; height a little over 1 mm."

I think it well here to observe in regard to this young specimen that there is room for considerable doubt whether it belongs to the genus *Holopus.* There are but five arms, forming a tightly closed pyramid, without any sign of an axillary plate such as should appear at any post-larval stage of *Holopus;* and the facets for the reception of the arm bases incline inward, instead of outward or horizontal as in typical specimens. In the latter respect it is more like the fossil genus *Cyathidium,* described in 1847 by the Danish author Steenstrup, from the upper chalk of Denmark; and also in the tightly closed pyramid, which has by the later discoveries of Brunnich Nielson[7] been shown to be the condition of the arms in *Cyathidium,* which however has at least three axillary pieces.

Dr. P. Herbert Carpenter in 1884[8] gave a very detailed account of this genus. He defined the family Holopidæ as follows:

"Basals and radials completely anchylosed into an asymmetrical tube-like calyx which is fixed by an irregular expanded base. On the upper edge of the cup are five unequal articular surfaces for the attachment of the second radials [*i.e.,* IBr]. Arms ten, massive, and closely inrolled. Disk relatively small, with a central mouth protected by five oral plates, between which and the edge of the cup is a very narrow irregular pave-

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[7] Crinoiderne i Danmarks Kridtaflejringer, 1913; Jaekel in Pal. Zeitschr., 1914, p. 390.

[8] Challenger Reports, part 32, Stalked Crinoids, pp. 197-217.

ment of smaller plates. Anus probably present, but not yet observed.''

Speaking of the first specimen acquired by Sir Rawson Rawson, he states that it was placed by him in the hands of Prof. Louis Agassiz during the stay of the ''Hassler'' at Barbados in 1872. Prof. Agassiz intended to publish a full description of the specimen, but was prevented from doing so by failing health, and after his death the figures which he had prepared were published by Mr. Alexander Agassiz, together with a short descriptive note by Count Pourtalès. He says that this specimen was subsequently entrusted by Sir Rawson Rawson to Sir Wyville Thomson, together with two others which he had obtained in 1876 after the publication of Pourtalès' notice of the first one.

He says that the second of the specimens mentioned by Sir Wyville Thomson seems to have been the original specimen described by Pourtalès, from which the oral plates had dropped away; and as it was gradually falling to pieces from natural decay Sir Rawson Rawson allowed it to be dissected. The figures on plate 3 of the ''Challenger'' report, with the exception of fig. 2, and figs. 1-4 on plate 5, show the results of this process. Fig. 2 on plate 3 is a slightly idealized view of the interior of the cup so as to show the oral plates of the large specimen represented in plate 2. This was supposed by Sir John Murray to belong to Sir Rawson Rawson, and Carpenter says that as it corresponded to the first specimen on Sir Wyville's list he imagined this to be the case; but Sir Rawson Rawson did not recognize it as his, and Carpenter, therefore, concluded that it is the mutilated dry specimen which Professor Agassiz told him was sent by him to Sir Wyville with permission to cut it up for details. In like manner Sir Rawson Rawson thought it possible that the original of plate 4 might be his young specimen mentioned by Sir Wyville as only about 8 mm. in height, but as Professor Agassiz told Carpenter that he also sent Sir Wyville a small individual, Carpenter believed that two specimens had somehow been mislaid. The specimen which was shown at the Philadelphia Exhibition, and was subsequently bought by the Museum of Comparative Zoology, was the original of plate 1 of the ''Challenger'' report. It was obtained by Mr. Wilderboer, the collector for Sir Rawson Rawson, after the latter had left Barbados, and having come into the hands of Alexander Agassiz, it was sent by him to Sir Wyville Thomson, together with the *Holopus* material obtained during the dredging expeditions of the ''Blake.'' This consisted of the very young individual dredged at Station 22, off Bahia Honda, Cuba, in 100 fathoms, and a single post-radial series dredged at Station 157, off Montserrat, in 120 fathoms.

Carpenter noticed that the pentagonal figure indicating the position of the fulcral ridges on the articular faces of the radials, and the central canals, can be traced almost to the bottom of the hollow cylinder forming the column. From analogy with other crinoids he believed that the small portion of the calyx tube between the limit of the pentagonal figure and the ends of the central canals and the spreading base consists of closely anchylosed basals, the presence of which was taken for granted by Sir Wyville Thomson. He found that the calyx tube narrows rapidly downward, and its interior is marked by five vertical ridges corresponding with the radials in position. They are fairly distinct at the level of the section just above the portion formed by the supposed basals, but become less marked as they proceed downward, and, being composed of the whiter, less dense, network, disappear together with it. They extend upward to the edge of the cup at the intermuscular notches, although they are much less distinct on some of the radials than on the others. They thus occupy the position of the ventral radial furrows which are often so marked on the interior of the calyx in other crinoids.

Carpenter pointed out that on the bivial arms of the large specimen in the collection of the Museum of Comparative Zoology (No. 5 in the appended list of known specimens; Cat. No. 21, M.C.Z.) there are two primibrachs which look as if they were articulated rather than suturally united, while on the trivial arms there is only one. He believes that the evidence is sufficient to bear out the statement that *Holopus* has two primibrachs which are closely united by syzygy; he says that we should accordingly expect to find a similar syzygial union between the first and second brachials, but that of this there is no evidence whatever. He notes the complete absence of syzygies in the arms.

Carpenter noted that the outer surfaces of the axillaries are produced dorsally for a considerable distance beyond the edges of the articular faces, as is the case with all the lower brachials, and they fit very closely against their fellows, their sides being flattened and more or less marked by ridges and furrows which interlock with those on the adjacent axillaries; these furrows are also apparent on the sides of the lower brachials. The muscle plates of the axillaries, and in a lesser degree also those of the brachials, are greatly thickened, and their upper edges are cut out into coarse teeth.

There is a large food groove on the upper surface of each arm and pinnule. The large size of the paired flexor muscles uniting the brachials would seem to give the power of rolling in the arms very rapidly and completely, while the small, but very close and compact, bundles of elastic ligaments on the dorsal side of the articular ridges would help in the re-extension of the arms.

In both the larger and better developed trivial and the smaller bivial arms a variable number of the lower brachials are considerably larger than those which follow, and the passage from one type to the other is usually somewhat sudden; on the trivial arms there are generally from eight to ten of these large massive brachials, but on the bivial there are only about seven, six, or even less. The shape of these lower brachials is rather variable; they may be roughly oblong, as is the case with the first two or three, or their edges may be oblique so as to give them a truncated wedge-like form. The more wedge-shaped these brachials are, owing to the obliquity of their terminal faces, the greater is the inequality in the size of the muscle plates on the two sides of the median groove. The pinnule socket of these wedge-shaped brachials is on the thickened upper edge of the higher muscle plate. The general character of these lower brachials is much less regular and symmetrical than is the case in other crinoids, so that many of them are more or less of an aberrant nature. In some few cases the brachial is smaller than usual, and triangular, not extending completely across the arm, so that the brachials above and below it come into contact with one another; sometimes, again, a first brachial becomes unusually large. The longest arms seem to have about eighteen small distal brachials, raising the total number of brachials to between twenty-five and thirty.

The longer outer sides of all the brachials bear the pinnules. That of the first brachial is comparatively small, and is attached close to the distal edge of the segment; the next pinnule is invisible in all the specimens, but those of the third and following brachials are much larger and have broad basal segments that gradually come to occupy more and more of the whole surface of the brachials to which they are attached; in fact the bases of the pinnules of alternate brachials that are borne upon the same side of the arm are only just separated from one another by the narrow ends of the intervening brachials which have their pinnules on the opposite side. The pinnules are rolled in upon themselves in exactly the same way that the arms are. The four or five basal segments are very broad, but the rest of the pinnule tapers away rather rapidly. The segments are united by paired muscular bundles, which is a somewhat unusual condition.

The central mouth is protected by five large and triangular oral plates which are opposite the clavicular pieces of the united radials. The lateral edges of these plates are more or less cut into false teeth, while the raised central portion is pierced by from fifteen to twenty minute holes, the water pores. The bases of the orals seem sometimes to rest directly against the edge of the radials, while they are sometimes separated from this edge by an irregular row of small triangular plates. Carpenter says it is not unlikely that an anal tube is concealed somewhere or other among these plates, but he saw no certain traces of it in the dry specimen.

The food grooves which come away from the mouth between every two of the oral plates are continued out upon the axillaries and thence on to the arms. They occupy the deep channel between the large muscular processes at the sides of the segments, and in the dry specimen appear to be bordered by small irregular plates. These, however, do not seem to correspond either to the side plates or to the covering plates of other crinoids, for an examination of the spirit specimen shows that these small plates really belong to the tentacles, which are relatively large and stout. The bases of these tentacles are protected by scale-like plates formed of the usual calcareous reticulation; they are not easily made out at the edges of the brachial groove, but on the lower parts of the pinnules there seem to be from two to three tentacles on either side of each segment.

The general arrangement of the tentacles is the same as in other crinoids, but the epithelial layer covering them is, if anything, thinner than in *Heliometra glacialis,* though thrown into much stronger corrugations at the ends of the tentacles.

Carpenter found that cutting sections of a *Holopus* arm was an exceedingly difficult task, partly because of the rolled up condition, and partly because the calcareous substance of the skeleton is so much denser than that of other crinoids, so that the organic base which is interpenetrated by it and remains behind after decalcification has nothing like the consistency that we meet with in the corresponding parts of the comatulids or of *Ilycrinus.* The presence of large bundles of muscles and ligaments without any helping syzygies also increases the difficulty of all attempts to obtain thin sections.

He found that the anatomy of a *Holopus* arm is similar in all essential respects to that of an ordinary crinoid. The axial cord traversing the central canal of the skeleton gives off its pinnule branches in the usual way, that is, alternately on opposite sides. These branches have a long distance to go before they reach the pinnules, owing to the attachment of the latter on the upper edges of the large muscle plates. As long as the branch remains in the substance of the brachial it does not take a straight course as is the case in the other crinoids, but is thrown into a series of loops in a dorsoventral direction, and after it enters the pinnule its course is still somewhat sinuous. These branches, like the main arm trunk, are relatively of very small size, which is perhaps to be accounted for by the fixed position of the animal. All the ambulacral structures of the *Holopus* arm are lodged in the deep median groove of its skeleton, and are usually small in comparison with the great transverse diameter of the ossicles. The cœliac canal is situated, as usual, between the two large muscle bundles, with a small genital canal separating it from the single subtentacular canal above. The epithelial lining is very much the same in character in all these canals, consisting of low, flattened cells. In *Holopus* the difference between the excessively delicate epithelial layer lining the wall of the genital canal and the well developed cellular lining of the cœliac and subtentacular canals is much less marked than in other types. The genital cord is of essentially the same nature as in the other crinoids, though it is of a much less branching character in the axillary than is usually the case so near the disc. It is connected with ovaries alternately on opposite sides of the arm from about the first to the fifteenth brachial. The ovaries are short and stout, and confined to the pinnule bases in the broader lower parts of the arms; but where the segments are smaller the ovaries appear immediately beneath the water vessel, and the boundaries between the three arm canals cannot be traced. The ova, of which all stages are visible, are more like those of *Heliometra glacialis* than is the case in many comatulids, but they are somewhat larger, reaching a diameter of 0.22 mm., while 0.1737 mm. is the size of the largest ovum of *Heliometra glacialis* which was measured by Ludwig.

Carpenter remarks that all the specimens of *Holopus* which have been preserved in the dry state are of a dull dark green tint, sometimes verging on black; but Mr. Agassiz records that on one occasion, off Montserrat, the "Blake" dredged an imperfect whitish specimen.

Carpenter treated one of the dry specimens of *Holopus* with alcohol and obtained a dull green solution with a red fluorescence. Professor Moseley examined this with the spectroscope, and found the coloring matter to be identical with the pentacrinin which he had discovered in the pentacrinites dredged by the "Challenger" in the Pacific and in the East Indian archipelago.

Carpenter discussed at considerable length the systematic position and relationships of *Holopus;* he associated with it in the family Holopidæ the genera *Eudesicrinus, Cyathidium* and *Cotylecrinus.*

In 1891 Jaekel[9] in a paper "Ueber Holopocriniden" discussed the genus *Holopus,* associating with it in the same family Holopocrinidæ the genera, *Cyrtocrinus, Schlerocrinus, Tetanocrinus, Gymnocrinus, Eugeniacrinus, Phyllocrinus* and ? *Tormocrinus.*

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[9] Zeitschr. d. Deutsch geol. Gesell. XLIII, Heft 3, p. 612.

In 1913 Springer and Clark[10] placed *Holopus,* together with *Cotyloderma* (*Cotylecrinus*) and *Cyathidium* (*Micropocrinus*) in the family Holopidæ, the last (eighth) family of the order Articulata as understood by them.

From a detailed study of the contrasting pairs of characters used in differentiating the recent crinoids Mr. A. H. Clark in 1915[11] arrived at the conclusion that *Holopus* is in reality a highly specialized type, on a par with, or even possibly in advance of, the pentacrinites and the comatulids, and much in advance of all the other recent forms. In 1919[12] the same author expressed the opinion that, in spite of their extraordinary superficial dissimilarity, the pentacrinites, the comatulids and *Holopus* are very closely related. He says that in the pentacrinites the column is enormously developed; so rapid is the growth that the proximales as they are continuously formed beneath the calyx never succeed in becoming attached to it, but are continuously pushed outward by the formation of new proximales between the last formed and the calyx; the proximales later become separated by the intercalation of other columnals, appearing in the fully developed column as the cirriferous nodals. The basals are much reduced and lie horizontally. In the comatulids a short column is formed and a proximale appears which, becoming firmly attached to the calyx, increases enormously in size, and, the larval column being discarded, contains the entire adult stem. The basals, in nearly all the types, become metamorphosed into an internal septum and entirely lose their original character. The base therefore is entirely composed of radials, practically horizontal in position, plus the proximale. In *Holopus* the same line of specialization has apparently been followed further; the column and the basals have disappeared, and the attachment is by means of the radials, which in the comatulids dominated the base. It is conceivable that the very young *Holopus* is essentially like a short-stemmed comatulid in which the radials, growing very rapidly, form a cylindrical ring with the basals, spread outward until they all lie in the same

10 In Zittel-Eastman, Text-book of Paleontology. 2nd Edition, p. 241.

11 Phylogenetic study of the Recent Crinoids, *Smiths. Misc. Coll.*, 65; no. 10 (Aug. 19, 1915).

12 Jour. Washington Acad. Sci., IX (1919), p. 136.

plane, closing the proximal end, and that this ring becomes attached by its lower border to the object upon which the larva rests.

THE KNOWN SPECIMENS OF HOLOPUS RANGII

1. Martinique (Pl. I, figs. 1, 2).

Caught by a fisherman and given to M. Sander Rang while still alive; by him presented to M. Alcide d'Orbigny, who described it in 1837.

Figured by d'Orbigny in "Magasin de zoologie, 7ieme annee, classe X, pl. 3, 1837."

Purchased by the Muséum d'Histoire Naturelle at Paris, and there examined by Sir Wyville Thomson in 1867.

Type of *Holopus rangii* d'Orbigny, 1837, this species being the type of the genus *Holopus.*

2. Barbados (Pl. I, fig. 3).

Found in 5 fathoms, but at first thought to have been brought up from "deep water."

Originally in the collection of Sir Rawson W. Rawson.

Governor Rawson sent a sketch of it, with a short note, to Dr. J. E. Gray, both of which were published by the latter in 1871. The specimen was not sent to Dr. Gray.

During the visit of the "Hassler" to Barbados in December, 1871, Governor Rawson loaned this specimen to Professor Louis Agassiz for the latter to describe and figure. His figures with a description by Count Pourtalès were published, after his death, in 1874.

This is probably the first specimen listed by Sir Wyville Thomson in 1877.

Figured by J. E. Gray, "Annals and Magazine of Natural History," series 4, vol. 8, 1871, p. 394; (L. Agassiz) Pourtalès, Illustrated Catalogue of the Museum of Comparative Zoology, vol. 4, No. 8, February 1874, pl. 10, figs. 1-9.

Type of *Holopus rawsoni* Gray, 1871.

In the British Museum.

3. Barbados.

Originally in the collection of Sir Rawson W. Rawson.

This is the second specimen listed by Sir Wyville Thomson, which was boiled down to allow of the description of the disassociated parts.

Figured by P. H. Carpenter, "Challenger" Reports, part 32, Stalked Crinoids, 1884, pl. 3, figs. 1, 3-16; pl. 5, figs. 1-8.

Destroyed.

4. Barbados (Pl. I, figs. 4, 5).

Originally in the collection of Sir Rawson W. Rawson.

This is the third specimen listed by Sir Wyville Thomson, which was "quite perfect, but very young, only 8 mm. in height."

Figured by P. H. Carpenter, "Challenger" Reports, part 32, Stalked Crinoids, 1884, pl. 4, two figures.

In the British Museum.

5. Barbados (Pl. I, figs. 6, 7).

Collected by Wilderboer, the collector for Sir Rawson W. Rawson, after the latter had left Barbados.

This specimen was shown at the Philadelphia Exhibition, and afterwards purchased by the Museum of Comparative Zoology, Cambridge, Massachusetts.

Figured by P. H. Carpenter, "Challenger" Reports, part 32, Stalked Crinoids, 1884, pl. I, figs. 1, 2.

In the Museum of Comparative Zoology (Cat. No. 21).

6. Cuba; off Bahia Honda (23° 01′ N. lat., 83° 14′ W. long.); 100 fathoms. Dredged by the "Blake" in 1877, Station 22 (Pl. II, figs. 10, 11).

Figured by Pourtalès, Bulletin of the Museum of Comparative Zoology, vol. 5, No. 9, 1878, pl. 2 (opposite p. 213); P. H. Carpenter, "Challenger" Reports, part 32, Stalked Crinoids, 1884, pl. 5, figs. 9, 10.

In the Museum of Comparative Zoology (Cat. No. 22).

7. Montserrat; 120 fathoms; "Blake" Station 157.

An incomplete specimen, most of which was dissected by P. H. Carpenter; the only one ever examined before being dried.

Figured by P. H. Carpenter, "Challenger" Reports, part 32, Stalked Crinoids, pl. 5*a*, figs. 1-3, pl. 5*b*, figs. 1-5, 5*c*, figs. 1-3.

In the Museum of Comparative Zoology (Cat. No. 23; part of an arm).

8. Bermuda.

Mentioned by Sir Wyville Thomson in "The Atlantic," London, 1877, p. 321. P. H. Carpenter says: "During the stay of the "Challenger" at Bermuda Sir Wyville Thomson obtained from a local collector 'a small worn and rounded fossil which seemed to be the cup of a crinoid allied to Holopus.' Prof. Moseley tells me that he thinks it was a recent specimen in the dry state; but since it has unfortunately been lost, I am unable to say anything as to its nature.''

9. ? Locality (Pl. II, figs. 8, 9).

P. H. Carpenter says: ''This was supposed by Mr. [Sir John] Murray to belong to Sir Rawson Rawson . . . .; but Sir Rawson Rawson does not recognize it as his, and I conclude, therefore, that it is the mutilated dry specimen which Prof. Agassiz informs me was sent by him to Sir Wyville with permission to cut it up for details.''

It cannot be the same as No. 2, as it is not distorted, and has seven arms remaining instead of only six.

Figured by P. H. Carpenter, ''Challenger'' Reports, part 32, Stalked Crinoids, 1884, pl. 2, two figures; pl. 3, fig. 2.

Present location not known.

10. Barbados.

A specimen at present in the hands of a dealer at Bridgetown.

11. Barbados (Pl. III, figs. 12-16).

The specimen described below, in the author's collection now in the United States National Museum. It was obtained from a local dealer by the Messrs. Ward of Rochester, New York, from whom I purchased it about twelve years ago; it was said to have been picked up on the shore after a storm.

A NEW SPECIMEN OF HOLOPUS RANGII

The specimen is quite complete, having the normal number of arms, 4 in the bivium and 6 in the trivium. The color is a dull dark green. The height, measured from the base of attachment, is 35 mm.; diameter at zone of greatest width, 23 mm.

It is believed that a few figures of this specimen reproduced from photographs will furnish a useful addition to our knowledge of this singular form.

In view of the ample descriptions quoted in the preceding pages it seems unnecessary to describe the specimen in detail; but I would like to call attention to the oral plates, which are extremely well preserved, Carpenter's figure of them being as he said, ''somewhat idealized.'' Although they lie within a dark cavity, Dr. Wilson has succeeded by the use of a powerfully projected light in securing a photograph with sufficient enlargement to show the structure of these plates with a minuteness of detail never before obtained; the perforation by the water-pores is remarkably distinct. The depth and narrowness of the groove on the ventral surface of the arms, in which the soft structures lie, should also be noticed.

PLATES

PLATE I

Figures of *Holopus* from various authors

Fig. 1. The type specimen of *Holopus rangii*, from Martinique; No. 1 in the list of known specimens (from d'Orbigny).

Fig. 2. The same specimen; transverse section of stalk to show the internal structure (from d'Orbigny).

Fig. 3. The type specimen of *Holopus rawsoni*, from Barbados; No. 2 in the list of known specimens (from Gray after Rawson).

Fig. 4. A young specimen from Barbados only 8 mm. in height; No. 4 in the list of known specimens (from P. H. Carpenter) x 5.

Fig. 5 Another view of the same specimen (from P. H. Carpenter) x 1½.

Fig. 6. The largest specimen examined by Carpenter, from Barbados; No. 5 in the list of known specimens (from P. H. Carpenter) x 1½.

PLATE I

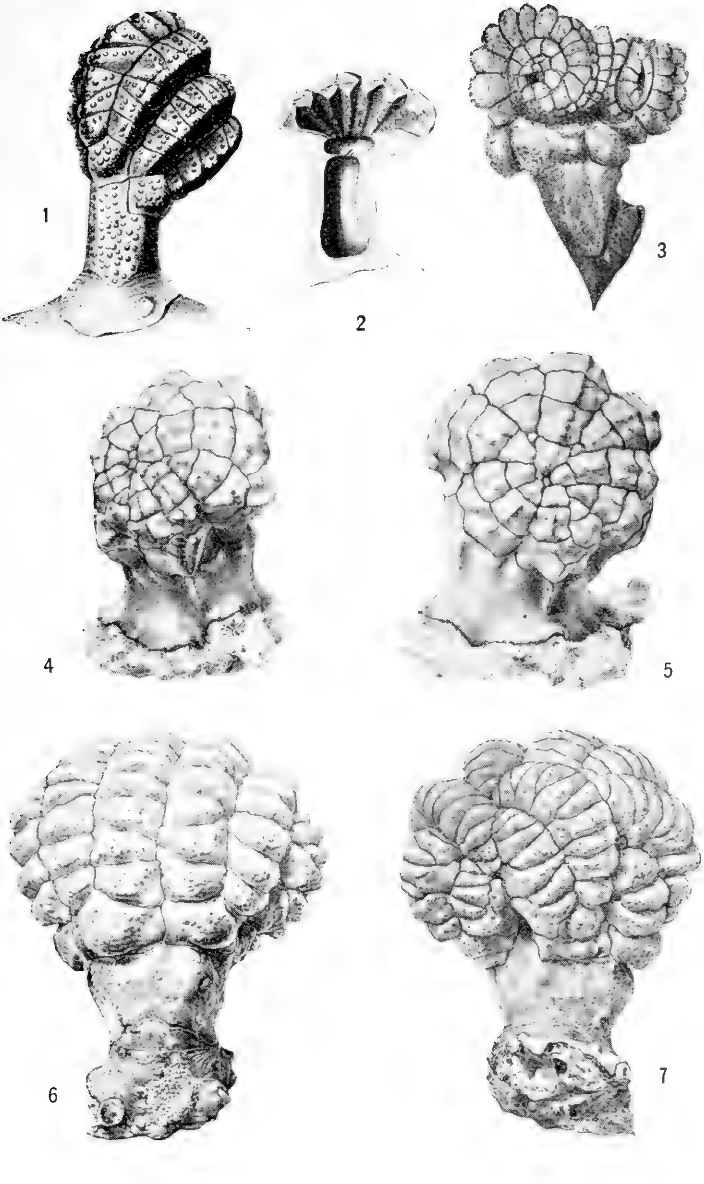

PLATE II

Figures of *Holopus* from various authors

Fig. 8. A specimen of unknown origin; No. 9 in the list of known specimens (from P. H. Carpenter) x 1½.

Fig. 9 Another view of the same specimen (from P. H. Carpenter) x 1½.

Fig. 10. A very young specimen from Cuba, viewed from above; No. 6 in the list of known specimens (from Pourtalès) x 15.

Fig. 11. The same specimen, viewed from the side (from Pourtalès) x 15.

PLATE II

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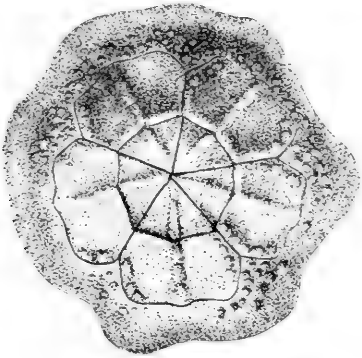

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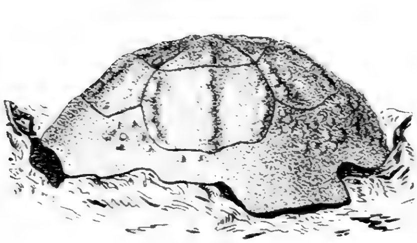

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PLATE III

A hitherto unrecorded specimen of *Holopus rangii* from Barbados

Fig. 12. Lateral view of complete crown with encrusting base, from the trivial side. x 4/3

Fig. 13. Lateral view of interior, with bivial and one trivial arms removed; showing position of orals within a deep cavity . x 4/3

Fig. 14. Ventral view of same structures; articulating surface of brachials is well shown. x 4/3

Fig. 15. The orals: unretouched photograph. Note the water-pores, and remnants of minute plates in the ambulacral furrows and some between the proximal ends of the orals and surrounding plates. x 5

Fig. 16. Terminal part of an arm, showing the position of pinnules upon alternate brachials. x 8/3

The specimen is in the author's collection, now in the United States National Museum.

PLATE III

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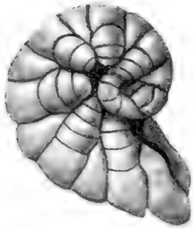

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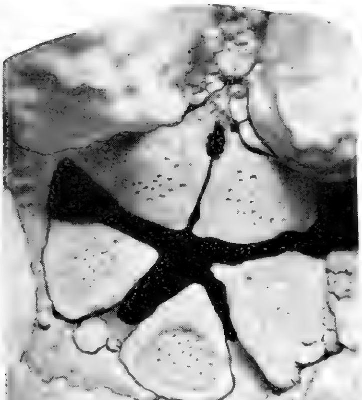

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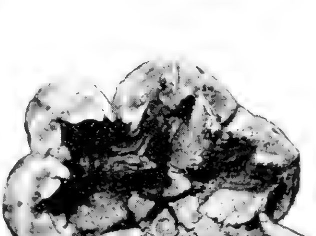

14

REPORT ON THE MACRURA, ANOMURA AND STOMATOPODA

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

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INTRODUCTION

Until now scarcely more than fifty[1] valid species of macruran, anomuran, and stomatopod crustacea have been recorded from or within the hundred fathom line off Barbados. Though the Expedition secured a little less than half, twenty, of these, it did return forty-one other valid species, four doubtful determinations, at least four "species?" and two distinct varietal forms, of which probably all except three from Antigua, noted below, constitute new records; these additions are:

Penæopsis smithi Schmitt
Sicyonia edwardsi Miers
Leptochela carinata Ortmann
Crangon candei (Guérin)
Crangon barbadensis, new species
Crangon cristulifrons (Rathbun)
Crangon rathbunæ, new species
Crangon verrilli, new species
Crangon nuttingi, new species
Crangon packardi (Kingsley)
Crangon, species ?
Synalpheus fritzmülleri elongatus Coutière
Synalpheus minus (Say)
Synalpheus brevicarpus (Herrick), variety?
Synalpheus mcclendoni Coutière
Synalpheus pandionis Coutière
Synalpheus herricki Coutière?
Synalpheus, species near *lævimanus* (Heller)
Synalpheus, species?

[1] Based on the reports cited in the Bibliography.

Jousseaumea trigona Rathbun
Automate kingsleyi Hay
Trachycaris rugosus (Bate)
Lysmata intermedia (Kingsley)
Thor paschalis (Heller)
Macrobrachium savignyi (Bate)
Macrobrachium, species?
Periclimenes antiguensis, new species
Xiphocaris elongata (Guérin)
Ortmannia serrei Bouvier
Panulirus argus (Latreille)
Petrolisthes marginatus Stimpson
Petrolisthes jugosus Streets
Petrolisthes amœnus (Guérin)
Pisosoma riisei Stimpson
Porcellana sayana (Leach)
Porcellana soriata Say
Pachycheles ackleianus Milne-Edwards
Pachycheles pilosus (Milne-Edwards)
Upogebia affinis (Say)
Upogebia (*Gebiopsis*) *operculata*, new species
Glypturus branneri Rathbun
Glypturus acanthochirus Stimpson?
Callianidea lævicauda Gill
Paguristes grayi Benedict
Clibanarius tricolor (Gibbes)
Petrochirus bahamensis (Herbst)
Dardanus venosus (Milne-Edwards)
Catapagurus, species?
Lepidopa scutellata Stimpson?
Gonodactylus oerstedii var. *curacaoensis* Schmitt
Gonodactylus oerstedii var. *spinulosus*, new variety

As will be noted, there are included six apparently new species and one new variety: *Crangon barbadensis, C. rathbunæ, C. verrilli, C. nuttingi, Periclimenes antiguensis, Upogebia* (*Gebiopsis*) *operculata*, and *Gonodactylus oerstedii* var. *spinulosus.*

The twenty species — or their synonymical forms — which seem to have been listed as occurring at, or off Barbados, within the hundred fathom line, are:

Crangon nigrospinatus (Rankin)
Crangon formosus (Gibbes)
Crangon cylindricus (Kingsley)
Crangon armillatus (Milne-Edwards)
Crangon bahamensis (Rankin)

Synalpheus longicarpus (Herrick)
Tozeuma serratum (Milne-Edwards)
Macrobrachium jamaicense (Herbst)
Stenopus semilævis von Martens
Parribacus antarcticus (Lund)
Munida irrasa Milne-Edwards
Munida iris Milne-Edwards?
Petrolisthes galathinus (Bosc)
Petrolisthes tridentatus Stimpson
Petrolisthes magnifica (Gibbes)
Megalobrachium poeyi (Guérin)
Calcinus tibicen (Herbst)
Cœnobita clypeatus (Herbst)
Hippa cubensis (Saussure)
Gonodactylus oerstedii Hansen

Three species not represented in the Barbados collections were taken at Antigua: *Sicyonia edwardsii* Miers, *Periclimenes antiguensis,* new species, *Paguristes grayi* Benedict.

I am indebted to Dr. Mary J. Rathbun for helpful guidance in the determination of this collection, and to Professor Nutting for the opportunity afforded of studying it; in appreciation of these facts, I have named one of the several new species for each of them. The pen and ink drawings of the new species were made by Mr. J. F. Müller of the U. S. Bureau of Fisheries.

The types are in the Museum of the State University of Iowa.

LIST OF SPECIES

Order DECAPODA

Family **Peneidæ**

Penæopsis smithi Schmitt

Penæopsis smithi Schmitt, Macruran, Anomuran and Stomatopod Crustacea, collected at Curaçao by Dr. C. J. van der Horst in 1920. Bijdragen tot de Dierkunde, Amsterdam, XXIII (1924), p. 62, text figs. 1, 2.

Bathsheba; 8 ♂ 4 ♀. Pelican Island, tide pools, May 11; 2 ♀. English Harbor, 3; 1 ♂.

Of the four females taken at Bathsheba, the third abdominal somite of the two larger specimens, respectively 48 and 49 mm. in length, shows distinct though not at all prominent longitudinal carination for about the middle third of its length, or a little more. This carina, such as it is, is low and inconspicuous and does not rise above the general level of the surface of the somite, being scarcely more than indicated by two slight pubescent depressions one either side of the median line of the middle third of the dorsum, and very unlike the well marked, raised carina found on the third somite of *P. goodei.* This carina is not in evidence in the males, in the smaller, 28 and 38 mm. long, Bathsheba females, or in the two from Pelican Island, of which the larger, 45 mm. long, individual is about the size of the 43.5 mm. long, type female from Curaçao. It seems almost that the weak carination is but an indication of full maturity in the female sex. The distinctive thelycum, and the slender median point of the telson still sharply differentiate this species, as does to a lesser degree the non-carinated third abdominal somite of the males and younger females, and the weakly carinated third somite in the more mature females; the larger males, of more than 40 mm. in length do show a faint angle only, across the posterior end of the median line of the third abdominal somite, the merest suggestion of a carina, if it can be recognized as such at all.

Sicyonia edwardsii Miers

Sicyonia edwardsii Miers, Ann. Mag. Nat. Hist., (5), VIII (1881), p. 367. Milne-Edwards and Bouvier, Mem. Mus. Comp. Zoöl., XXVII, no. 3 (1909), p. 251, pl. 8, figs. 1-3.

English Harbor, electric light; 1 ♀.

Family **Pasiphaeidæ**

Leptochela carinata Ortmann

Leptochela carinata Ortmann, Dekapoden u. Schizopoden, Ergeb. d. Plankton Exped., XLI (1893), pl. 4, fig. 1. Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 127.

Sta. 87; 1 ♀ ovig. Sta. 79; 1 ♀ ovig.

Family **Crangonidæ**

Crangon candei (Guérin)

Alpheus candei Guérin, *in* La Sagrás Hist. Cuba, pt. 2, VII (1857), p. 19, pl. 2, fig. 9; Coutière, Proc. U. S. Nat. Mus., XXXVII (1910), p. 486, text fig. 1.

Alpheus dentipes Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 105.

Alpheus candei or *Crangon candei* Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 68, text fig. 5b; pl. 19, figs. 3a-d; pl. 20, fig. 1; pl. 21, figs. 6, 6a; pl. 24, figs. 2-4; pl. 25, figs. 7, 8; pl. 29, figs. 1a-t.

Off the Castle, E. side Barbados, 1-4 fathoms; two specimens. Pelican Island, May 13; three specimens. From coral rock, May 31; two specimens.

Based on published descriptions there are few, if any, valid differences distinguishing this species from the Mediterranean *C. dentipes* of the same author.[1] The entire National Museum collection of Alpheids is in the hands of Dr. Coutière, Ecole Supérieure de Pharmacie, Paris, so it is not possible to add much regarding either species at this time. Coutière seems to have considered the Tortugas specimen he referred to *C. candei,* as quite distinct from *C. dentipes,* as he does not even mention the latter in his redescription of the former (*loc. cit.*).

The only possible difference that I am able to detect at the present time, in view of our limited knowledge of *C. candei,* is in the shape of the movable finger of the larger hand. Coutière figures this (*loc. cit.,* fig. 1 b, b^1) as gradually tapering toward the more or less acuminate tip, which is much more slender, not as wide or thick as the finger is at the middle of its length; in *C. dentipes* it seems that the movable finger has a more or less swollen, blunt, or truncated end, the finger being at least as thick or thicker terminally than at the middle of its length. However this may be, Verrill appears to have had both types of hands represented among his Bermuda *candei.* His plate

[1] Guérin, Expéd. Sci. Morée, Zool., (1832), p. 39, pl. 27, fig. 3.

19, figures 3c and 3b, and plate 21, figure 6, show a tapering movable finger, while figures 3a, and 3d, on plate 19 seem to have the movable finger terminally blunt and swollen. They are so in the specimens I have here, and recently elsewhere[2] referred to this species.

Whether this difference is constant, and so of specific or at least of varietal value, or possibly dimorphic, I am unable to say . Guérin's figure of the movable finger, by the way, reproduced by Verrill (pl. 25, figure 8), might be of either character.

Coutière's specimen lacked the second legs; Verrill's drawing (*loc. cit.*, pl. 29, figs. 1 l', 1 l'' a) of one of the members of this pair agrees with the specimens before me, but the type of larger chela possessed by the specimen in question is not ascertainable from the text. As regards the legs of the third pair, in my specimens as in Verrill's the merus carries below at the distal end a small spine, and such a spine is also present in Coutière's *C. candei,* which I have examined, though not detected by him, for he described the merus as unarmed.

Crangon barbadensis, new species

Off the Castle, E. side Barbados, 1-4 fathoms (type locality); 2 ♂ 4 ♀ (2 ovig.). Off the Crane, Barbados, from old coral rock; 1 ♀. Pelican Island, Barbados, tide pool; two specimens.

This species is one of a small group having the outer margin of the antennal scale armed with a more or less forwardly directed spine or spine-like process. The only other species, similarly armed, of which I am aware, are *C. malleator* (Dana)[3] and *C. belli* Coutière[4] from Fernando Noronha. The front, rostral carina and orbital depressions somewhat resemble *C. cristulifrons* (Rathbun) (below, p. 73), though the carina is faintly discernible for a greater distance behind the posteriorly sharply demarked, orbital depressions; the orbital hoods are unarmed, being anteriorly rounded; the antennular peduncles are quite slender, the first joints are maybe one-third longer than the terminal ones, and the second about twice as long as the first, a little better than three times the third, and nearly four times as long as wide; in this respect our species differs markedly from *C. belli,* which is otherwise more nearly related possibly

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[2] Macruran, Anomuran and Stomatopod Crustacea collected at Curaçao by Dr. C. J. van der Horst in 1920. Bijdragen tot de Dierkunde, Amsterdam, XXIII (1924), p. 64.

[3] Dana, Crust. U. S. Expl. Exped., I (1852), p. 557; atlas, 1855, pl. 31, figs. 9a-h. Coutière, Ann. Sci. Nat., Zool., Paris, (8), IX, p. 146, text fig. 140, p. 219, fig. 262.

[4] Bull. Soc. Ent. France, (1898), p. 149, text figs. 1, 1a.

than any other species; *C. belli* has comparatively stout antennular peduncles, the longest, the middle joint being less than twice as long as wide, but equal to the length of the first, and one-half the third taken together; the antennular scale reaches but two-thirds the length of the basal joint of the peduncle, in *C. belli* about to the end; the basal antennal scale is longer, attaining about the distal margin of the first joint of the antennular peduncle; the antennal scale, though much shorter than the antennal peduncle is yet considerably longer than the antennular peduncle, exceeding it by a little more than the length of the distal joint, the scale is almost all ''spine'' as the blade is much reduced in size, and short; in *C. belli* the antennal scale about equals the antennal peduncle in length; the large hand is notched above and below; the fingers of the smaller chela about equal the palm in length, the movable one being more or less *Balæniceps*-shaped in the male; the carpal joints of the second legs diminish in the following order, 1, 2, 5, 4, 3; the first equals the second and third together, or a little more, the fourth is a little longer than the third, the fifth equals the combined length of the third and fourth articles or two-thirds of the second; here again *C. belli* differs markedly from our species, as Coutière says, the first carpal joint of the second legs equals two-thirds the length of the first; in our species the first is as long as the second and third together; the meri of the third and fourth legs are stout, and not spined beneath.

The telson is quite rectangular with a slightly convex, squarish, truncate end, and subparallel sides; it is deeply sulcate on the median line, and the dorsal spines are inserted on prominent longitudinal ridges, either side of the median groove; the 4.75 mm. long telson of the type is about 2.5 mm. wide at its distal extremity and 3 mm. wide proximally.

The carapace and rostrum of the male holotype from off the Castle, E. side of Barbados, measure 14 mm. long; abdomen and telson 20 mm., telson 4.75 mm. large hand 18 mm. long, 7 mm. wide; small hand 12.3 mm. long, 4 mm. wide.

Crangon nigrospinatus (Rankin)

Alpheus nigro-spinatus Rankin, Ann. N. Y. Acad. Sci., XI (1898), p. 249, pl. 30, fig. 6.

Alpheus malleator var. *edentatus* Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, 1913, p. 387, text figs. G-M.

Off the Castle, E. side of Barbados, 1-4 fathoms; 1 ♂ 2 ♀. Off the Crane, Barbados, from old coral rock; one specimen. Barbados, from coral heads, June 4; four specimens.

Except in a few minor points the specimens before me agree well with Rankin's description. The rostral point is a little longer than the orbital spines and not just equal to them in length; on the inner side of either orbital spine there is a slight convexity in the frontal margin, the rounded border of the orbital hood passing over more abruptly into the inner margin of the spine than on the outer side. The antennular scale, as figured by Rankin appears to be but half the length of the first joint of the peduncle, in our specimens it is almost as long as the first joint; basal antennal spine as long as the antennular scale not exceeding the first joint of the peduncle as in Rankin's figure. The groove on the outer surface of the immovable finger of the larger hand is more marked or evident than shown in Rankin's figure of the species. The second and fifth carpal articles of the second legs are each a little shorter than half the first; Rankin says a little longer than half the first, but in his figure, while the second article is about equal to half the first, the fifth is less than half.

Zimmer considered a specimen from Barbados, which undoubtedly represents this species, a variety of *C. malleator* (Dana).[5] Dana's species differs, however, in a number of important characters: the rostrum is quite flattened, broad and "under-cut" at the sides, in *nigrospinatus* it is but a dorsally blunt carina; the small accessory or secondary teeth on the orbital hoods, between the orbital hoods and the rostrum are well marked in specimens of *C. malleator* as small as 15 mm. long, in *nigrospinatus* the corresponding portion of the medial border of the orbital hoods shows no more than a slight convexity if that; the antennular scale is shorter than the first segment of the peduncle, the second segment is scarcely, if twice the length of the third; the basal antennal spine reaches nearly to the middle of the second segment of the antennular peduncle; the antennal scale is but very little longer than the antennular peduncle and shorter than the antennal peduncle, in *C. nigrospinatus* the spine of the scale is as long as the antennal peduncle being distinctly longer than the antennular peduncle. *C. malleator* is a very distinctive species by virtue of the outwardly directed, forward turned, process near the base of the outer margin of the antennal scale (already referred to, above, p. 70); this proximo-lateral angle has surely been exaggerated in Zimmer's figure (G) of his Barbados specimen, but even so, it is yet quite unlike the long tubercular, or spine-like basal projection of *C. malleator;* in *C. nigrospinatus,* this outer, proximal

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[5] Crust. U. S. Expl. Exped., I (1852), p. 557, atlas (1855), pl. 31, figs. 9a-h.

angle of the antennal scale, is not at all noticeably produced; the groove which runs the length of the outer face of the immovable finger of the larger hand of *C. malleator* is longer than in *C. nigrospinatus* in that it extends back on to the palm for a distance about equal to its length in front of that point; moreover the upper margin and a considerable portion of the inner faces of both chelae are distinctly tubercular in *C. malleator,* and the same areas merely punctate in *C. nigrospinatus,* though hairy in both species; the dactyls of the ambulatory legs are biunguiculate in both species though the fact is not mentioned by Rankin, nor discernible in his figure of *C. nigrospinatus.*

Crangon formosus (Gibbes)

Alpheus formosus Gibbes, Proc. Amer. Assoc. Adv. Sci., III (1850), p. 196 [32]; Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 106.

Alpheus panamensis Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 391, text figs. N-V.

Alpheus formosus or *Crangon formosus* Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 84, text fig. 5d, ? text fig. 6a; pl. 19, figs. 1, 2; pl. 20, fig. 3; pl. 23, fig. 5, a, b; pl. 20, fig. 4, a-u; pl. 25, figs. 6, 6a.

Pelican Island, tide pool, May 11; 1 ♀ ovig. Barbados, from coral heads; one specimen. English Harbor, 7; 1 ♀ ovig. English Harbor; one specimen.

The second and fourth specimens are without chelae, and though the rostra look somewhat like *C. panamensis* (Kingsley) as figured by Coutière,[6] the second legs by comparison are like the unmistakably *formosus* forms. What the relations of the carpal joints of the second legs of *C. panamensis*[7] are, I do not know.

Crangon cristulifrons (Rathbun)

Alpheus obeso-manus Pocock, Jour. Linn. Soc. London, Zool., XX (1890), p. 520, (*nec* Dana).

Alpheus cristulifrons Rathbun, Proc. Wash. Acad. Sci., II (1900), p. 152; Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 106.

Okra Reef, Barbados, 16, May 13; three specimens. Barbados, May 15; 6 (3 ovig.). Barbados, May 22; one specimen.

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[6] Ann. Sci. Nat., Zool. Paris, (8), IX (1899), p. 89, text fig. 50.

[7] Kingsley, Bull. U. S. Geol. Survey, IV, art. 8 (1878), p. 192.

Crangon cylindricus (Kingsley)

Alpheus cylindricus Kingsley, Bull. U. S. Geol. Survey, IV, art. 8, (1878), p. 192. Coutière, Ann. Sci. Nat., Zool., Paris, (8), IX (1899), p. 81, text fig. 44, p. 228, text fig. 278. Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 394.

D.S. 1, May 13; one specimen. D.S. 20; 2 (1 ovig.). Barbados, May 15; one specimen.

After examining the specimens here listed, with front and large chela closely approximating Coutière's figures, of which the first only is cited by Zimmer, I find I must have been mistaken recently[8] in thinking his specimens should be considered as *C. cristulifrons* (Rathbun). From this species *C. cylindricus* differs in having an unkeeled rostrum, a characteristic large chela, figured by Coutière (*loc. cit.*, text fig. 44), quite different from the rather *Synalpheus*-like hand, though with thick, curved, swollen finger, of *C. cristulifrons* not greatly unlike the hand of *C. crinitus* also figured by Coutière (*loc. cit.*, p. 226, text fig. 273); the second legs have differently divided carpi, in *C. cylindricus* as Kingsley has it, "carpus of second pair jointed, first pair equalling the following three; second as long as third and fourth which are equal, fifth longer than fourth," while in *C. cristulifrons* "the carpal joints of the second pair diminish as follows: Second, fifth, first, fourth and third; the second being as long as the third, fourth and fifth together" (Rathbun); in the latter the meri of the third and fourth legs are spined beneath, in the former they are unarmed.

Crangon rathbunæ, new species

D.S. 20; 3 (1 ovig.). Okra Reef, Barbados, May 13; 20 (7 ovig.). Barbados, May 15; 4 (1 ovig.). Needham's Point, Barbados, May 18; 5 (3 ovig.); the complete ♀ is the type. Barbados, coral rock, May 31; 9 (4 ovig.). Barbados from coral heads, June 4; 3 (1 ovig.).

A species which resembles some of the members of the *obeso-manus* group of "Alpheids,"[9] though the dactyl does not seem quite so typically hammer-shaped.

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[8] Macruran, Anomuran and Stomatopod Crustacea, collected at Curaçao by Dr. C. J. van der Horst in 1920. Bijdragen tot de Dierkunde, Amsterdam, XXIII (1924), p. 65.

[9] Coutière, Ann. Sci. Nat. Zool., Paris (8), IX (1899), p. 351. De Man, Siboga Exped., monog. XXXIX a[1], Decapoda, pt. 2, Alpheidæ, (1911), p. 307.

The emarginate front is very *Betaeus*-like, having much the shape and form of Bate's figures of his *C. malleodigitus* and *microstylus*,[10] especially the latter. The smooth, shining carapace is membranous, and subglobular or inflated to the extent of being strikingly Pontonid-like. For the sub-group to which this species is here assigned, the slender antennules and antennæ represent probably an extreme development; the median segment of the antennular peduncle is about six and one-half times as long as wide, about three times as long as the first, and four times the third segment; the flagella are about as long as the peduncle and nearly of the same length, the thicker being a little shorter than its companion; the antennal peduncle reaches about one-third the length of the median antennular segment, and its flagellum one-sixth its length beyond the longer, thinner, antennular flagellum; the antennal scale is more or less reduced though from two-thirds to three-fourths the length of the antennal peduncle, blade not differentiated from spine; the antennular scale likewise very small, being a mere basal lobule on the outer side of the first joint of the peduncle.

The more or less cylindrical larger hand is about three times as long as wide (high); the longer diameter of the movable finger is a little less than the distal width of the palm, in dorsal view behind the articulation of the finger; the larger hands of the smaller specimens are relatively more slender, more cylindrical, and with proportionately, slightly larger movable fingers; the smaller chela is long and slender in the few specimens retaining the first legs; this hand of the pair is as long as the palm of the larger hand from the articulation of the movable finger to the base; the slender, similar fingers of the smaller chela in length about equal two-thirds the plam. The first carpal joint of the second legs is about four-fifths of the second and longest; the third, fourth and fifth are nearly all of the same length, their combined length making up just half of the entire length of the carpus; the third is slightly shorter than the fourth and this in turn is a little less than the fifth in length; the chela is as long as the fourth and fifth joints taken together; the fingers equal about two-thirds the palm, or two-thirds of the entire hand in length. The meral joints of the ambulatory legs are unarmed beneath, that of the third legs being just a little better than three times as long as its greatest width.

The triangular telson is most peculiar for an Alpheid: there are no dorsal spines, and either margin is armed at about one-eleventh the length of the telson from the distal lateral angles, with a small spine; the end of the telson carries three pairs of spines of which the "sub"-median pair is the largest and the external the smallest; between the submedian spines there are about seven principal setae and a number of shorter ones; the greatest width of the telson near its base is just about three-fifths its length, the width of the distal extremity about one-seventh.

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[10] Challenger Rept., Zool., XXIV, [pt. 52] (1888), pp. 565 and 566, and pl. 101, figs. 5 and 6, respectively.

The specimens de Man[11] and Coutière [12] identify with Bate's *malleodigitus* and *microstylus* already referred to, are figured as showing small rostral points or projections; however, Coutière did have three specimens of the latter species with the emarginate front described by Bate as typical, Coutière thinks the latter anomalous in view of their limited occurrence in his material; in the thirty odd specimens of *C. rathbunæ* there are none with other than the emarginate front.

The ovigerous female, designated as the type is smaller than the dissected, figured specimen: the carapace is 5 mm. long, the abdomen and telson 11, telson 2.5; the large hand is 6.2 mm. long and 2.3 mm. wide; the small hand 4.2 mm. and its movable finger measured from the articulation to the tip 1.75 mm. long.

C. baculifer Coutière[13] is the only other species of the *obesomanus* sub-group having the meri of the third legs unarmed, these joints are three and six-tenths times as long as wide at the middle; the second joint of the second legs is little longer than the first, and about as long as the third and fourth together, the third is very little shorter than the fourth, which is subequal to the fifth; the cylindrical large hand is five and a half times as long as wide; and the median joint of the antennular peduncle is one and one-half times as long as either of the other two.

Crangon armillatus (Milne-Edwards)

Alpheus armillatus Milne-Edwards, Hist. Nat. Crust., II (1837), p. 354. Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1912), p. 401, text figs. K^1-T^1.

Alpheus heterochœlis Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 107 (pars).

Alpheus armillatus or *Crangon armillatus* Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 73, text figs. 5a, 6b; pl. 20, fig. 4b; pl. 21, figs. 4, 4a; pl. 23, fig. 4; pl. 26, figs. 1-1d; pl. 27, figs. 1-1s, and synonymy.

Pelican Island, shallow; one specimen. Pelican Island, tide pool; one specimen. Pelican Island, tide pool, May 11; 6 (3 ovig.). Pillars of Hercules, English Harbor, 4; one specimen. Pillars of Hercules, English Harbor; 3 (1 ovig.).

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[11] *Op. cit.*, pp. 347 and 344, and pl. 14, figs. 70 and 68, respectively.

[12] Fauna Maldive and Laccadive Archipelagoes, II, pt. 4 (1905), p. 886, pl. 77, fig. 25, and p. 884, pl. 76, fig. 23, respectively.

[13] Bull. Soc. Philom. (9), X (1908), p. 206 [16]; see also de Man *op. cit.*, p. 314.

Crangon verrilli, new species

Alpheus armillatus or *Crangon armillatus* Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 76, pl. 48, figs. 2-2n (part: specimen referred to on page 76, as *armillatus* var., "No. 735-b").

Barbados, in dead *Strombus* shells, May 29; 2 (1 ovig.); the ovigerous female is the type.

A species closely related to the preceding, but distinctive enough to be readily recognized. The rostrum in both species has the form of a sharp crest, which in *C. armillatus* widens abruptly behind into a flattened triangular area, which may be a little undercut at the sides, but anteriorly is continuous with and about on the level with the rostral crest; in *C. verrilli* behind the rostral crest there is an abrupt inverted flattened U-shaped area deeply undercut at the sides, and anteriorly except just where it is joined by the rostral crest, this in profile is quite concave longitudinally, and lies noticeably below the level of the U-shaped area; on either side between the rostral crest and the orbital hoods are well marked orbital depressions distinctly limited behind by the $\triangle$ area in A. *armillatus* and the ∩-shaped area in *C. verrilli*. In the former the rostrum appears to run forward only about half the length of the visible portion of the basal antennular segment, in the latter about or nearly to the end of that segment.

The antennules and antennular scales are about the same in both species; the blade of the antennal scale seems to be slightly narrower in *C. verrilli* and the basal antennal spine a little longer.

The hands of the first legs, though very similar, are a little differently proportioned in the two species: measured on the outer face along the median longitudinal axis. The portion of the hand lying before the line connecting the notches in the upper and lower margins of the hands is just about as long as the posterior moiety; in *C. armillatus* the posterior portion is but about two-thirds as long as the anterior portion. The smaller hand in *C. verrilli* is three times, or a little more, as long as the greatest width of the palm; in *C. armillatus* the length is from two and two-thirds to not exceeding two and three-fourths the greatest width.

The carpal joints of the second legs appear to have about the same relative length in both species; the joints diminish as follows: First, second, fifth, fourth, third; the first is as long as the second and third together, the second is from two-thirds to three-fourths the length of the first, the fourth appears a little longer than the third, the fifth is equal to the fourth and nearly half the third together.

The carapace and rostrum of the ovigerous female holotype measure 15 mm. in length, the abdomen and telson 25, and the telson 5 mm. long; the larger chela is 16 mm. long and 6.5 mm. wide.

Crangon bahamensis (Rankin)

Alpheus hippothoë var. *bahamensis* Rankin, Ann. N. Y. Acad. Sci., XI, no. 12 (1898), p. 247, pl. 20, fig. 5.

Alpheus hippothoë var. *edamensis* ? Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 405, text figs. U1-Z1.

Alpheus bahamensis Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 70, pl. 20, figs. 6, 6a, pl. 28, figs. 1, a-11, 2, 3-31.

Barbados, from coral heads, June 4; 7 (4 ovig.).

Crangon nuttingi, new species

Barbados from coral heads, June 4; one specimen. Pelican Island, tide pool, May 11; three specimens. Pelican Island, shallow (type locality); 1 ♂ 1 ♀ ovig., 1 juv.

Near *C. bahamensis* (Rankin). The rostrum extends forward about to the distal margin of the basal segment of the antennular peduncle; it is carinated, and the carina extends back behind the orbital hoods for about half its length; anteriorly, the rostral crest is distinctly keeled and prominent, posteriorly though higher, is broader and less conspicuous; the orbital hoods are unarmed and the rostro-orbital depressions are not sharply delimited behind, going over more or less gradually into the dorsum of the carapace. The antennular scale is as long as the first segment of the peduncle or a little longer; the antennal scale is scarcely, if at all longer than the antennal peduncle, the blade only reaches about to, or a little past the middle of the distal segment of the antennular peduncle, in *C. bahamensis* on the other hand the spine of the scale is distinctly longer than either the antennular or antennal peduncles; the basal antennal spine is short in both species; their larger chelae do not differ noticeably; the upper distal angle of the merus of the larger cheliped of *C. bahamensis* is markedly produced forming a blunt, spine-like process as figured by Rankin, though described by him as a sharp spine; such a spine does occur at the anterior inner angle of the merus; in our species the upper distal angle is not at all produced, being rounded off, and there is no spine at the inner angle; the fingers of the smaller chela are about as long as the palm. The second pair of legs have the first carpal joint longer than the second, in fact equalling the combined length of the second, third, and fourth articles together, the second joint is a little longer than the fifth, about one-seventh longer, the third is a little longer than the fourth, the two together are scarcely longer than the fifth; in *C. bahamensis* the first joint is shorter than the second, about two-thirds or three-fourths its length, the second equals the third, fourth, and half the fifth joints together, the third is a little shorter than the fourth which is in turn a little shorter than the fifth, the third is about two-thirds the length of the fifth joint, the fourth about three-fourths. The meri of the third and fourth legs are unarmed below, thus differing from *C. bahamensis* in which they are armed; the dactyls are simple in both species.

The carapace and rostrum of the male holotype together equal 14 mm. the abdomen and telson, 20.5, and the telson 4 mm.; the large hand is 20 mm. long by 8 wide, at widest point, the small hand is 10.5 mm. long by 3.5 mm. the greatest width of the palm.

This species differs from *C. heterochælis,* with which it also might be confused, in having a sharply carinated and longer rostral crest; the rostral crest too, is higher, rising just behind the orbital hoods and a little above their level, the hoods themselves are more abruptly domed, making the orbito-rostral depressions appear deeper and more sharply defined than in *C. heterochælis.* Furthermore, in the latter the blade of the antennal scale is about or nearly as long as the spine, distally truncate, bluntly rounded off, and three or four times wider than the adjacent portion of the spine; both blade and spine exceed the antennular peduncle; in *C. nuttingi* the spine exceeds the antennular peduncle a little and exceeds the blade considerably, the latter reaching about to the middle of the last segment of the antennular peduncle, distally it is sharply rounded off and narrow, scarcely wider than the adjacent portion of the spine. Paralleling the lower margin, on the inner face of the larger hand of *C. heterochælis* there is a distinct sulcus running from the notch to the articulation of the carpus, of which there is no trace in *C. nuttingi,* the inner face of the hand being merely a little flattened above the lower margin; moreover, the inner face of the fingers, and anterior portion of the palm are very hairy, while in *C. heterochælis* the hairs are few, and mostly marginal, so that the inner face of the hand is practically naked; in these particulars the larger hand of our species is like that of *C. armillatus.*

Crangon packardii (Kingsley)

Alpheus packardii Kingsley, Proc. Acad. Nat. Sci. Phila., XXXI, 1879 (1880), p. 417; Bull. Essex Inst., Salem XIV (1883), p. 118 [14], pl. 2, fig. 2. Zimmer (spelled *packardi*), Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 409, text figs. A^2-G^2.

Alpheus packardii or *Crangon packardii,* Trans. Conn. Acad. Sci., XXVI (1922), p. 80, pl. 20, figs. 2, 5; pl. 21, fig. 5; pl. 22, fig. 7; pl. 23, figs. 6c-d; pl. 25, figs. 4, a, b; pl. 31, figs. 1, b-l, 2, b-u, 3, u, t.

D.S. 1, May 13; one specimen. Barbados, from coral heads, June 4; one specimen.

Crangon, species ?

English Harbor, two incomplete specimens; front near *C. cylindricus* (above) but with much more slender ambulatory legs.

Synalpheus fritzmülleri elongatus Coutière

Synalpheus fritzmülleri Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 35, text figs. 18, 19. Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 382.

Okra reef, Barbados, May 13, 16; 8 (2 ovig.). Pelican Island, May 13; four specimens. Barbados, May 15; 16 (7 ovig.). Needham's Point, Barbados, May 18; 3 (1 ovig.). Barbados, May 22; four specimens. Barbados, coral rock, May 31;

3 (1 ovig.). Barbados from coral heads, June 4; 7 (4 ovig.). Barbados, 51; 1 ♀ ovig.

Synalpheus minus (Say)

Alpheus minus Say, Jour. Acad. Nat. Sci. Phila., I (1818), p. 245.—Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 43, text figs. 25-27.

? *Synalpheus minus* Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 382.

Off Lord's Castle, Barbados, from sponges, 4-6 fathoms; four specimens. Off Lord's Castle, Barbados, from sponge in which strange tube dwelling annelid was found; one specimen. Off the Castle, E. side Barbados, 1-4 fathoms; 2 (1 ovig.). Barbados, from coral heads, June 4; four specimens.

Synalpheus brevicarpus (Herrick), variety ?

Alpheus saulcyi var. *brevicarpus* Herrick, Mem. Nat. Acad. Sci., V (1891), p. 383.

Synalpheus brevicarpus Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 50, text figs. 29, 30.

Okra Reef, Barbados, May 13; four specimens. Pelican Island, Barbados, May 13; one specimen.

These specimens in many ways seem to represent *S. minus antillensis*, but having the *S. brevicarpus guerini* rostrum and lacking a spine on the upper angle of the basicerite, it seems that they had best be considered as a variety of *S. brevicarpus.*

In this connection I have examined specimens in the collections of the U.S. National Museum determined by Prof. Coutière. It appears that some of the specimens labelled *S. minus* have the basicerite more as in his figure of *S. brevicarpus guerini*, and that in the specimens of the type lot of the latter, that the basicerite is spined above as figured for *S. minus antillensis.* Did not the rostra of these several specimens so closely resemble the figures whose labels they bear, I would be inclined to think that they had become interchanged.

Having such a well developed spine at the upper angle of the basicerite, Coutière's specimens are *S. saulcyi* (Guérin) more certainly than he suspected at the time (*op. cit.*, p. 52).

Synalpheus longicarpus (Herrick)

Alpheus saulcyi var. *longicarpus* Herrick, Mem. Nat. Acad. Sci., V (1891), p. 383 (part).

Synalpheus longicarpus Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 53, text figs. 31, 32.—Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 384, text fig. B.

Barbados, May 15; one specimen. D.S. 20; one specimen.

Synalpheus mcclendoni Coutière

Synalpheus mcclendoni Coutière, Proc. U. S. Nat. Mus., XXXVII (1910), p. 487, p. 3.

D.S. 1; 5 specimens.

Synalpheus pandionis Coutière

Synalpheus pandionis Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 67, text fig. 39.—Zimmer, Zool. Jahrb., Suppl. 11, hft. 3, (1913), p. 385, text figs. C-E.

Okra Reef, Barbados, 16, May 13; three specimens.

? *Synalpheus herricki* Coutière

Synalpheus herricki Coutière, Proc. U. S. Nat. Mus., XXXVI, 1909, pl. 71 text fig. 44.

Barbados; one specimen.

The smaller hand is wanting, and though not unlike *S. brooksi* Coutière (*op. cit.*, p. 69), the larger chela is not spined anteriorly as it is in that species; moreover the spines on the telson are larger and the joints of the antennular peduncle a little more slender than in *S. brooksi.*

? *Synalpheus,* species near *lævimanus* (Heller)

Synalpheus lævimanus Coutière, Proc. U. S. Nat. Mus., XXXVI (1909), p. 66, text fig. 38.

Needham's Point, Barbados, May 18; one specimen.

The front is like that figured by Coutière for *S. goodei occidentalis* (*op. cit.*, p. 59, and text fig. 34) but the telson has a wider posterior margin and the outer border of the outer branch of the uropods is not serrulate; the blade of the antennal scale is relatively as long as in the figured male of *S. goodei* Coutière (*op. cit.*, p. 58, text fig. 1a) and the sharp almost spinous upper angle of the basicerite is similarly produced.

Synalpheus, species ?

(incomplete specimens not determined).

D.S. 1; one specimen. D.S. 20; one specimen. D.S. 78; three specimens (dried). Needham's Point, Barbados, May 18; one specimen.

Jousseaumea trigona Rathbun

Jousseaumea trigona Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 111, text fig. 21.

Barbados, in *Strombus* shells, May 29; one specimen without legs.

Automate kingsleyi Hay

Automate kingsleyi Hay, Proc. Biol. Soc. Washington, vol. 30, 1917, p. 72. Hay and Shore, Bull. U. S. Bur. Fisheries, XXXV, 1915-16, (1918), p. 387, text fig. 10.

Pelican Island, Barbados, tide pool; one specimen. Pillars of Hercules, English Harbor; two specimens.

This species is not unlike *C. evermanni* Rathbun,[14] but as the first and second legs are more like those of the species described by Hay, I have so determined them.

Family **Hippolytidæ**

Trachycaris rugosus (Bate)

Platybema rugosus Bate, Challenger Rept., Zool., XXIV, [pt. 52], (1888), p. 579, pl. 104, fig. 2.—Rathbun, Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 113.

Trachycaris rugosus Calman, Ann. Mag. Nat. Hist. (7) XXVII (1906), p. 33, *in "Notes on some Genera of the Crustacean Family* Hippolytidæ."

English Harbor, 8; one specimen.

Lysmata intermedia (Kingsley)

Hippolysmata intermedia Kingsley, Proc. Acad. Nat. Sci. Phila., XXX (1878), p. 90 [2].—Rathbun, Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 116.—Rapport van de Visscherij en de Industrie van Zee producten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 (1920), p. 322, [6].

Lysmata intermedia Kemp, Rec. Indian Mus., X, pt. 2, no. 4 (1914), p. 112.

D.S. 20; one specimen; Barbados, 7; one specimen.

Thor paschalis (Heller)

Hippolyte paschalis Heller, Sitzb. Akad. Wissen., Wien, XLIV (1861), p. 276, pl. 3, fig. 24.

Thor floridanus Kingsley, Proc. Acad. Nat. Sci. Phila., XXX (1878), p. 95 [7].—Rathbun, Bull. U. S. Fish. Comm., pt. 2, 1900 (1901), p. 116.—Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 (1920), p. 323 [7].—Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 135, pl. 35, figs. 2-2f; pl. 41, fig. 1; pl. 46, figs. 2-2e; pl. 47, figs. 4, 4a.

Thor paschalis Kemp, Rec. Indian Mus., X (1914), p. 95, pl. 1, figs. 6-10 and synonymy.—Rec. Indian Mus., XII (1916), p. 387.

Barbados, Needham's Point, diver; one specimen. Barbados Sea, anemones; one specimen.

D.S. 78; one specimen (dried).

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[14] Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 112, text fig. 22.

Tozeuma serratum Milne-Edwards

Tozeuma serratum A. Milne-Edwards, Ann. Sci. Nat., Zool., Paris, (6), XI, art. 4 (1881), p. 16; Recueil de Figures de Crustacés nouveaux ou peu connus, pl. 29, 1883.

D.S. 79; one specimen.

Family **Palæmonidæ**

Macrobrachium jamaicense (Herbst)

Cancer (Astacus) jamaicensis Herbst, Naturg. d. Krabben u. Krebse, II (1792), p. 57, pl. 27, fig. 2.

Bithynis jamaicensis Rathbun, Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 123.

Macrobrachium jamaicense Rathbun, Proc. U. S. Nat. Mus., XXXVIII (1910), p. 561, pl. 51, fig. 1.

Bathsheba, freshwater; 1 ♂. Scotland valley, Barbados, freshwater stream; 1 ♂.

Macrobrachium savignyi (Bate)

Brachycarpus savignyi Bate, Challenger Rept., Zool., XXIV (1888), p. 795, pl. 129, fig. 4.

Bithynis savignyi Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 124.

Palæmon savignyi Verrill, Trans. Conn. Acad., XXVI (1922), p. 145, text fig. 11.

Macrobrachium savignyi Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 (1920), p. 324 [8].

Needham's Point, Barbados, May 18; two specimens.

? *Macrobrachium*, species

Indian River, Barbados, May 21; three specimens.

Without the legs of the second pair which are wanting in each of these specimens, it is not possible to determine them satisfactorily. A rostral count gives 14 for two of the specimens and 15 for the third. One of the former is the largest of the three and measures about 27 mm. long; the rostrum is longer than the antennular peduncle and just about as long as the antennal scale, four of the dorsal teeth are on the carapace; the rostra are rather straight, the apices of the dorsal teeth being in about the same line which is inclined a little downwards from the third tooth to the tip; the first tooth is a little lower than the second, and the tip of the second is just below the level of the apex of the third which is the highest of the series. The shorter ramus of the bifurcate antennular flagellum is composed of 5-6 fused and 15-16 free articles; in one of the specimens the latter count rises to 20. The mandible has a three jointed palp. The hepatic spine is well developed, and as characteristic of the genus, is situated a little below and not far behind the antennal spine. The fingers and palm of the first legs are subequal, the carpus is about twice as long as the chela and about equal to the merus in length; the dactyls of the last three pairs of legs are simple, long and slender, about one-fourth the length of the propodus. The telson is about as long as half the fifth and the sixth segments of the abdomen taken together.

Periclimenes antiguensis, new species

English Harbor, Antigua, electric light, July, 1918; 1 ♂ holotype.

Rostrum straight, distally a little upturned, as long as rest of carapace, and about two and a half times as long as the antennular peduncle; armed above with nine teeth, of which the first is about over the distal margin of the second segment of the antennular peduncle; dorsal teeth regularly spaced, distance from last tooth to the acute tip twice that between last tooth and the penultimate one; below there are six teeth, the first of which is about under the third dorsal and the last a little in advance of the last dorsal, the second is under fifth dorsal and the third, fourth and fifth about under the intervals between the sixth, seventh, eighth and ninth teeth above; behind the first dorsal tooth the upper margin of the rostrum broadens out to form an elongate, narrow-triangular, flattened area on a level and confluent with the dorsum of the carapace; supra-orbital or rather orbital "spine" a blunt prominence, the anterior margin of which in dorsal view forms approximately a right angle with its lateral margin which is parallel to the longitudinal axis of the carapace; apex of the angle slightly produced, and blunt, a little behind the anterior margin of the carapace, and about in line, in lateral view, with the lower margin of the eye-stalk; antennal spine well developed, hepatic spine wanting.

Basally the upper, outer, thicker antennular flagellum appears considerably swollen, due to the short, thick, closely apposed accessory or secondary "flagellum" which it carries; this apparently is made up of four free segments, in addition to, possibly, two or three others which are fused with the primary flagellum; the enlarged external view of the right antennule with respect to the greater part of the base of the bifurcate flagellum is largely tentative, as the mass of thick hairs covering the lateral face of the accessory flagellum made it virtually impossible to satisfactorily determine the exact segmentation; just before the beginning of its distal third the lower, medial margin of the basal segment of the antennular peduncle carries a stout spine; the eyestalk reaches about to the middle of the second segment; the second segment of the peduncle is about half as long as the third, and the second and third together equal a little more than half, but not two-thirds the length of the visible portion of the first segment; the antennal peduncle is shorter than the eye-stalk, and in ventral view fails of reaching the distal margin of the basal segment of the antennular peduncle; antennal scale when directed straight forward about reaching the penultimate, dorsal, rostral tooth, the sharply angled inner, anterior ''corner'' of the blade is produced a little in advance of the spine.

The mandible is without a palp, and the third of the three maxillipeds alone, without an exopodite; the second, left maxilla somehow strayed in dissection, and the figured right seems to have lost its inner lobe or lobes, if present at all, though I suppose they must have been.

Chela of first legs slightly longer than the carpus and about seven-eighths the length of the merus; fingers a little more than two-thirds of the palm; there is a tuft of short hairs near the inner, ventral, posterior angle of the palm and another on the infero-distal angle of the carpus; only the left leg of the second pair is present, its fingers are long and slender, hooked at the tips and without teeth on their cutting edges, the movable finger is a little longer than the rest of the hand and the carpus taken together, the carpus two-fifths the length of the palm and very little longer than deep, merus a little more than four times the length of the carpus; ambulatory legs similar, dactyls slender, biunguiculate, without basal protuberance; dactyl of third leg slender, about two-fifths the length of the propodus and nearly half as long as the carpus; the carpus equals three-fourths the length of the propodus and about half or slightly more than half the length of the merus; propodus armed below with eight spines, including the one at the infero-distal angle.

The fifth and sixth abdominal somites are about of equal length, either being slightly less than half the length of the telson; abdominal pleura rounded beneath; telson long and narrow, tapering to the distal margin which is but one-fourth the width of the base of the telson; medially the telson is deeply sulcate, on the lateral ridges thus formed, there are two pairs of dorsal spines, the distal pair of which is just before the middle and the proximal pair at about one-sixth the length of the telson from its base; the sides, lateral margins, are about perpendicular to the dorsal surface; the distal margin of the telson is armed with two stout movable spines, attached to the middle of either half of the posterior margin, in width equalling one-fourth the length of the margin, and in length slightly exceeding it; at either postero-lateral angle is a small, slightly, inwardly curved spine in length equalling half the width of the adjacent large spine; between the pair of large spines are two slender, broken spines, or thick, stiff hairs diverging from either side of the slightly peaked mid-point of the posterior margin, the remaining portion of the longer of these slender spines is as long as the basal width of the large spines; the dorsal spines of the telson though as long as the posterior large spines, are much more slender, being half or less than half as thick or stout.

This species is put in the genus *Periclimenes* (*sensu latu*) for want of more suitable one. In Kemp's "Key to the genera of Pontoniinæ"[15] it falls in the same section with *Pontonides* and *Balssia* to either of which it certainly does not belong, though the third maxilliped is not unlike that of the former figured by Borradaile.[16] Except for the lack of the exopodite on this member, the species is more nearly a *Periclimenes* than otherwise. The bifurcation of the thicker antennular flagellum, the anteriorly sharply angled blade of the antennal scale, the absence of the hepatic spine, the long slender fingers of the second leg in conjunction with a short carpus, and the occurrence of both pairs of dorsal spines on the proximal half of the telson are somewhat unusual for the genus. The posteriorly flattened, dorsal margin of the rostrum bears some resemblance to that presented by Borradaile's dorsal view of *Periclimenæus fimbriatus*.[17]

The carapace and rostrum of the male hototype are each 4 mm. long, abdomen and telson 11 mm., and the telson alone 3 mm. long.

Family **Atyidæ**

Xiphocaris elongata (Guérin)

Hippolyte elongata Guérin, in La Sagra's Hist. Cuba, VII (1857), p. 20; VIII, pl. 2, fig. 16.

Xiphocaris elongata Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 118.

Indian River, Barbados; four specimens. Fresh-water, north of Bridgetown, Barbados; six specimens.

Ortmannia serrei Bouvier

Ortmannia serrei Bouvier, Bull. Mus. Hist. Nat., Paris, vol. 15, 1909, pp. 331, 332 [3, 4].

Bridgetown Beach, Barbados; one ovigerous female.

Family **Stenopidæ**

Stenopus semilævis von Martens

Stenopus semilævis von Martens, Archiv f. Naturg., XXXVIII (1872), p. 144.—Rankin, Ann. N. Y. Acad. Sci., XI, no. 12 (1898), p. 241, pl. 39, fig. 2.

English Harbor, 1; one specimen. English Harbor; one ovigerous female. Pelican Island, tide pool, May 11; one specimen.

Family **Palinuridæ**

Panulirus argus (Latreille)

Palinurus argus Latreille, Ann. Mus. Hist. Nat., Paris, III (1804), p. 393.

[15] Rec. Indian Mus., XXIV, pt. 2 (1922), pp. 119-121.

[16] Trans. Linn. Soc. London, (2), Zool., XVII, pt. 3 (1917), pl. 57, fig. 28.

[17] *Op. cit.*, pl. 55, fig. 19b.

Panulirus argus Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 98.—Verrill, Trans. Conn. Acad. Sci., XXVI (1922), p. 7, text fig. 1, pl. 1, fig. 1; pl. 2, figs. 1, 2; pl. 3, figs. 1, 2; pl. 3a, figs. 2-6; pl. 8, figs. 2, 2a; pl. 9, fig. 1.

From fish pot near Pelican Island; 1 ♂, measured from tips of supraocular horns to end of telson, 170 mm. long.

Bathsheba, Barbados; one specimen of "puerulus," or natant stage; very probably this species.

Family **Scyllaridæ**

Parribacus antarcticus (Lund)

Scyllarus antarcticus Lund, Skrivter af Naturhistorie-Selskabet, Copenhagen, II, hft. 2 (1793), p. 22.

Cancer (Astacus) ursus major Herbst, Naturg. d. Krabben u. Krebse, II (1793), p. 82, pl. 30, fig. 2.

Parribacus antarcticus Dana, Crust. U. S. Expl. Exped., I (1852), p. 517; pl. 32, fig. 6. 1855.

Parribacus ursus major de Man, Siboga Exped., Decapoda, pt. 3, monog. XXXIXa², . . . Scyllaridæ . . ., p. 93.

Barbados, H; 1 ♂.

I have preferred not to follow de Man in changing the long used name of this species. There is no indication in either the work of Herbst or Lund, as to which is the earlier; current usage is certainly in favor of Lund's *antarcticus*.

Family **Galatheidæ**

Munida irrasa Milne-Edwards

Munida irrasa A. Milne-Edwards, Bull. Mus. Comp. Zool., VIII (1880), p. 49.—Benedict, Proc. U. S. Nat. Mus., VIII (1902), pp. 251, 310.

Munida caribæa A. Milne-Edwards, Bull. Mus. Comp. Zool., XIX, no. 2 (1897), p. 25, pl. 1, figs. 16-20; pl. 2, fig. 1.

D.S. 3; two specimens. D.S. 7, Barbados, May 16; one specimen. D.S. 18; one specimen. Sta. 7, Barbados; four specimens. Sta. 49; two specimens. Sta. 51; two specimens. Sta. 59; two specimens. Barbados; two specimens.

Mostly small young specimens.

? *Munida iris* Milne-Edwards

Munida iris A. Milne-Edwards, Bull. Mus. Comp. Zool., VIII (1880), p. 49. Milne-Ewards and Bouvier, Mem. Mus. Comp. Zool., XIX, no. 2 (1897), p. 21, pl. 2, figs. 2-7.—Benedict, Proc. U. S. Nat. Mus., XXVI (1902), pp. 251, 310.

D.S. 1, May 13; one specimen. Sta. 42; one specimen (fragment). Sta. 78; one specimen (dried).

These are all small, probably juvenile specimens without the chelipeds, which because of the armature of the first abdominal somite are placed here.

Family **Porcellanidæ**

Petrolisthes galathinus (Bosc)

Porcellana galathina Bosc, Hist. Nat. Crust., I 1802, p. 233, pl. 6, fig. 2.
Petrolisthes sexspinosus Rathbun, Ann. Inst. Jamaica, I, no. 1 (1897), p. 40.—Proc. Wash. Acad. Sci., II (1900), p. 145.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 133.
Petrolisthes galathinus Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 (1920), p. 327 [11].—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 289, pl. 1, figs. 1, 2.

D.S. 20; 1 ♀ ovig. Okra Reef, May 13; 6 (2 ovig.). Barbados, May 15; one specimen. Barbados, May 22; one specimen. Old coral, May 31; 2 (1 ovig.).

Off the Castle, E. side Barbados; one specimen.

Petrolisthes tridentatus Stimpson

Petrolisthes tridentatus Stimpson, Ann. Lyc. Nat. Hist. N. Y., VII, 1859 (1860), p. 75 [29], pl. 1, fig. 4.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 134, pl. 3, fig. 2.—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 291.

Needham's Point, Barbados; two specimens. English Harbor; 4 (3 ovig.). Pillars of Hercules, English Harbor; 3 (1 ovig.).

Petrolisthes marginatus Stimpson

Petrolisthes marginatus Stimpson, Ann. Lyc. Nat. Hist. N. Y., VII, 1859 (1860), p. 74 [28].—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 134, pl. 3, fig. 1.

Okra Reef, Barbados, May 13; 4 (2 ovig.). Barbados, May 15; 8 (3 ovig.). Barbados, old coral, May 31; 3 (2 ovig.). Barbados, from coral heads, June 4; two specimens.

In alcohol, salmon color marked with reddish flecks usually along margins and on tubercles of chelipeds. Legs more or less banded with red, one on propodus, two on carpus, with red fleck, rather spot, on upper anterior margin of merus.

Petrolisthes jugosus Streets

Petrolisthes jugosus Streets, Proc. Acad. Nat. Sci. Phila., XXIV (1872), p. 134.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 134.

D.S. 1, May 13; 2 (1 ovig.). Okra reef, Barbados, May 13; 1 ♀ ovig. Barbados, May 15; 19 (13 ovig.). Old Coral, Barbados, May 31; 6 (3 ovig.). From coral heads, June 4; 11 (7 ovig.).

In coloration this species resembles *P. riisei* (below), has carapace lighter, finely speckled with white, meral joints of legs speckled, and others banded about midway. Abdomen speckled with white, like carapace, but median, intestinal line white.

Petrolisthes amœnus (Guérin)

Porcellana amoena Guérin, *in* La Sagra's Hist. Cuba, pt. 2, VIII, atlas (1857), pl. 2, fig. 2.

Petrolisthes ? amoenus Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 135, pl. 3, fig. 3.

D.S. 20; 2 ovig.

Engineers Pier, Barbados, 15-20 feet, from gorgonians; two specimens. Needham's Point, Barbados, May 18; 10 (3 ovig.). Off Needham's Point, from sponges, May 18, 20-25 feet; 6 (1 ovig.). Barbados, May 22; 3 (1 ovig.).

Petrolisthes magnifica (Gibbes)

Porcellana magnificus Gibbes, Proc. Amer. Assoc. Adv. Sci., III (1850), p. 191 [27].

Petrolisthes magnifica Benedict, Proc. U. S. Nat. Mus., XVI (1893), p. 539.—Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 (1920), p. 327 [11].

Porcellana polita? Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4, p. 293, pl. 1, fig. 7.

English Harbor; two specimens. Needham's Point, Barbados; one specimen. Pelican Island, tide-pool, May 11; 1 ♂. Pillars of Hercules, Antigua; 9 (4 ovig.).

Pisosoma riisei Stimpson

Pisosoma riisei Stimpson, Ann. Lyc. Nat. Hist. N. Y., VII, 1859 (1860), p. 75 [29].

Pisosoma glabra Kingsley, Proc. Acad. Nat. Sci. Phila., XXI, 1879 (1880), p. 406, pl. 14, fig. 2.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 135, pl. 3, fig. 5.

D.S. 20; one specimen. Okra Reef, Barbados, May 13; twenty specimens. Barbados, May 15; 7 (2 ovig.). Needham's Point, May 18; three specimens. Needham's Point, diver; one specimen. Old coral, May 31; 8 (4 ovig.). From coral heads, Barbados, June 4; 6 (3 ovig.).

In alcohol deep red, with postorbital, anterior shoulder of branchial regions and proximal half of leg joints white splotched, except in case of legs, in which the entire dactyl is whitish or pinkish), tips of fingers white. Abdomen white or reddish.

Megalobrachium poeyi (Guérin)

Porcellana poeyi Guérin, *in* La Sagra's Hist. Cuba, pt. 2, VIII, atlas (1857), pl. 2, fig. 4.

Megalobrachium poeyi Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 136, pl. 3, fig. 8.—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 297.

Pelican Island, tide pool; 11 (2 ovig.). Pelican Island, shallow, May 13; two specimens.

Porcellana sayana (Leach)

Pisidia sayana Leach, Dict. Sci. Nat., XVIII (1820), p. 54.

Porcellana sayana Benedcit, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 137, pl. 3, fig. 10, and synonymy.—Andrews, Zool. Anz., XXXVII (1911), p. 401, 2 text figs.—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 291, pl. 1, fig. 3.

Barbados in *Strombus* shell, May 29; 5 (1 ovig.). English Harbor; 1 specimen.

Porcellana soriata Say

Porcellana soriata Say, Jour. Acad. Nat. Sci. Phila., I (1818), p. 456.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 137.—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 294, pl. 4, fig. 1.

Needham's Point, Barbados, May 18; one specimen.

Pachycheles ackleianus A. Milne-Edwards

Pachycheles ackleianus A. Milne-Edwards, Bull. Mus. Comp. Zool., VIII (1880-81), p. 36.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 136.

Barbados; 2 ♀ ovig. Barbados, from coral heads, May 27; one specimen.

Pachycheles pilosus (Milne-Edwards)

Porcellana pilosa H. Milne-Edwards, Hist. Nat. Crust., II (1837), p. 255.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 137, pl. 3, fig. 11.—Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., XLVII, no. 4 (1923), p. 294.

specimen. From coral heads, Barbados, June 4; 6 (4 ovig.).

Off the Castle, E. side Barbados; two specimens.

Barbados, May 15; 5 (3 ovig.). Old coral, May 31; one

Family **Callianassidæ**

Upogebia affinis (Say)

Gebia affinis, Say, Jour. Acad. Nat. Sci. Phila., I (1817), p. 241.

Upogebia affinis, Hay and Shore, Bull. U. S. Bur. Fisheries, XXXV, 1915-16 (1918), p. 408, pl. 29, fig. 9.

Pelican Island, Barbados, shallow, May 14; 2 (1 ovig.).

Upogebia (Gebiopsis) operculata, new species

Okra Reef, May 13; 1 ♂ holotype. Okra Reef, 16, May 13; 1 ♀.

A new species which in the structure of its tail fan and the last two abdominal somites undoubtedly represents the Atlantic analog of "*Gebia*" [*Upogebia (Gebiopsis)*] *rugosa* Lockington.[18]

Rostrum in front of the line connecting the anterior spines of the lateral ridges of the gastric region, short, thick, rounded triangular, depressed, armed on each lateral border with two strong spines, the anterior pair situated at about or a little before the middle of the length of this frontal portion, the posterior pair situated within and anterior to the spines terminating the lateral gastric ridges, separated from them by the furrow lying just within either ridge, which at this point turns out to meet the frontal margin, behind these grooves, or furrows reach the cervical groove; between the two posterior spines of the front are two smaller spines, making a row of four across its base. In the holotype the lateral gastric ridges are armed with nine blunt, spiniform tubercles arranged in an anterior group of four larger spines and a posterior group of five smaller more separated tubercles; in the only other known specimen of this species there are from eleven to twelve tubercles on the lateral ridges. On the dorsum of the anterior portion of the carapace are four rather irregular rows of at times twined, paired, blunt spines, anteriorly these rows, the two either side of the mid-dorsal line, converge and apex, in the corresponding spine of the median pair of the basal line of the front, the mid-dorsal line of the anterior portion of carapace is somewhat grooved in its anterior half, posteriorly the rows become more irregular and harder to trace, the tubercles constituting them becoming smaller, less distinct and finally, virtually disappearing in the posterior third or fourth of the anterior portion of the carapace just before the cervical groove, where there are but one or two little granules to be found, the rostral, frontal, region of the carapace is thickly hirsute, while proximally before the cervical groove the anterior portion of the carapace is virtually without hairs. The antero-lateral portions of branchial regions are armed with a group of three or four or more small, spiniform granules.

The antennal peduncles exceed the rostrum by the length of the terminal joint and about the distal third or a little more of the penultimate joint taken together; antennular peduncle surpasses the proximal margin of the terminal joint of the antennal peduncle, and is slender and rather feeble as compared to the latter, in the paratype reaching one-third the length of the end joint of the antennal peduncle; flagella of antennules about equal in length, about as long as their peduncle, upper or outer flagellum the stouter composed of nineteen segments, thinner of fourteen.

There is but one cheliped to the two specimens, this was found in the

[18] Ann. Mag. Nat. Hist., (5), II (1878), p. 300.

vial containing the specimen selected, for this reason, as the holotype. Hand thick and stout, compressed but rounded above and below; both fingers short and stout; immovable finger the longer, and at first glance appearing to be furnished with a tooth at or just before the middle of its length, on closer inspection it is seen to be but indicated by a discolored or corneous area or interspace between the tip of the finger and the apparent tooth; the smooth palm has on its inner face a thin line of hair tufts on a level with the middle of the base of the movable finger extending back about to its posterior margin, and on the outer face with another more thickly set row of hairs extending obliquely from about the same level proximally, nearly to the base of the sinus between the fingers, where it curves abruptly downward to meet the lower margin of the palm, lower margin of hand with fringe of long hair for the greater part of its length; upper and lower margins of carpus unarmed, there is however a single, blunt tooth on its inner face near but below the upper distal angle, in line with the line of hair on the inner face of the palm; merus proximally broken off, below with fringe of long hair just within or on the medial side of the row of tiny, inconspicuous denticulations marking the inferior margin of the joint. The only legs attached to the body are those of the fifth pair of which the left leg is small and evidently regenerated; the right leg is imperfectly subchelate, propodus thick, hirsute, little shorter than carpus, about equal to the merus in length, dactyl, long, curved, tapering to a nearly acute tip, about twice as long as produced infero-distal angle of propodus constituting the fixed finger, and extending for half its length beyond it when folded against the distal margin of the propodus. Of the legs loose in the vial with the type specimen, one which may be taken as the second left leg has the merus subequal to or slightly shorter than the ischium, about one-third longer than the carpus and about as long as the propodus; propodus compressed with fringe of long hair on upper and lower margin, the stout three angled dactyl is about one-third as long as propodus.

The terminal portion of the abdomen of *U. rugosa* as described by Lockington applies equally well to the species before us. As he has it (*op. cit.*, p. 301), ''Posterior margin of fourth abdominal segment beset with short stiff hairs; the three posterior segments [inclusive of telson] and the lateral caudal appendages complexly wrinkled above, the rugae smooth. Terminal segment [telson] broader than long, distal margin longer than proximal; caudal processes large, filling up the space between the terminal and fifth segments.'' In our species the first three abdominal segments are dorsally smooth, as is likewise the fourth which carries a line of hair across its anterior third and a thick fringe, or brush of hair along its entire posterior margin sharply setting it off from the fifth somite; fifth and sixth somites ''complexly'' but symmetrically ''wrinkled'' telson and uropods with smooth rugae some of which bifurcate or are incomplete; proximal half of fifth somite and distal moiety of telson and of uropods longitudinally concave or transversely troughed for their entire, respective widths; tail fan when fully expanded forming with the fifth and sixth somites a striking and unique, operculiform disk, troughed within its distal half around the circumference and margined with a continuous thick fringe of hair; apparently to lock the elements of the disk together; the proximal half of the outer margin of the sixth somite carries two blunt prominences between and below which is a third more tooth or spine-like projection for the purpose of engaging the outer margin of the outer branch of the uropods.

From Lockington's *U. rugosa,* our species differs in the armature of the rostrum, and the extent of the tuberculation of the anterior portion of the carapace; *U. rugosa* has the "upper surface of rostrum and carapax, to about half way to the dorsal suture, beset with small tubercles and hirsute; and what is probably more significant, the dactylus seems to have been longer than the "pollex" in Lockington's species though his description is not wholly clear on this point: "dactylus less than half the length of the palmar portion of the hand which is thickly hirsute, curved, regularly downwards, its tip passing beyond that of the dactylus [pollex?]." It is apparently on the basis of this character that Borradaile[19] placed this species in the subgenus *Upogebia.* Surely it is a

[19] Ann. Mag. Nat. Hist., (7), XII (1903), p. 543.

Gebiopsis. Lockington does not mention a small tooth on the fore edge of the carapace over the antennae in describing his species, though he was well aware of its occurrence in the genus (*cf.* his remarks *op. cit.,* p. 300, on *Gebia* (*Upogebia*) *longipollex* Streets.) The relative length of the fingers of the Upogebias is so variable that it can scarcely be considered of having much weight even as a subgeneric character.

It would be interesting to know the application of the "operculum" in our species and Lockington's, the former are, as noted above, from Okra reef, Barbados, the latter from "under stones and coral at low tide Port Escondido, Gulf of California, August, 1876."

The carapace of the male holotype including the rostrum is 8 mm. long, anterior portion before the cervical groove and also including rostrum 4.5 mm.; abdomen and telson 14.5, telson 3.5 mm. long.

Glypturus branneri Rathbun

Glypturus branneri Rathbun, Proc. Wash. Acad. Sci., II (1900), p. 150, pl. 8, figs. 5-8.—Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 93.—Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2, (1920), p. 328 [12], text fig. 3.

Pelican Island, Barbados, shallow, May 14; one specimen.

? *Glypturus acanthochirus* Stimpson

Glypturus acanthochirus Stimpson, Proc. Acad. Sci., Chicago, I (1866), p. 46.

Barbados, from coral head, June 4; one small specimen about 19.5 mm. long.

The one hand remaining, apparently the larger is not spined on the inner surface near the upper margin, and the median point of the front, is more the narrow triangularly produced anterior margin of the carapace forming a flattened rostral point, than a more or less distinct spine as seems to be usual with larger specimens of this species; the smallest specimen available for comparison is not less than 43 mm. long from tip of rostral projection to end of telson. Our specimen may represent the juvenile or non-mature form of *G. acanthochirus.*

Callianidea lævicauda Gill

Callianidea lævicauda Gill, Proc. Acad. Nat. Sci. Phila., XI (1859), p. 167.—Rathbun, Bull. U. S. Fish Comm., XX, pt. 2, 1900, (1901), p. 94.

Needham's Point, Barbados; 3 (2 ovig.). Pelican Island, shallow, May 14; anterior portion of one specimen.

Family **Paguridæ**

Paguristes grayi Benedict

Paguristes grayi Benedict, Bull. U. S. Fish. Comm., XX, pt. 2, 1900 (1901), p. 146, pl. 5, figs. 1, 1a.

Antigua, 9, Jan. 7; 1 ♂.

Clibanarius tricolor (Gibbes)

Pagurus tricolor Gibbes, Proc. Amer. Assoc. Adv. Sci., III (1850), p. 189 [25].

Clibanarius tricolor Stimpson, Proc. Acad. Nat. Sci. Phila., X (1858), p. 234.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 142, pl. 6, fig. 2.

Pelican Island; 50 (4 ovig.). Pelican Island, shallow; two specimens.

The larger lot of specimens is unmistakably this species, as the color is still well marked.

Calcinus tibicen (Herbst)

Cancer tibicen Herbst, Naturg. d. Krabben u. Krebse, II (1791), p. 25, pl. 23, fig. 7.

Calcinus sulcatus Benedict, Proc. U. S. Nat. Mus., XVI (1893), p. 539.—Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 141, pl. 5, figs. 3, 3a.—Verrill, Trans. Conn. Acad. Sci., XIII (1908), p. 439, text figs. 56, 57, pl. 28, fig. 7.—Rathbun, Proc. Wash. Acad. Sci., II (1900), p. 144.

Calcinus tibicen Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2, (1920), p. 329 [13].

No label, three specimens.

Petrochirus bahamensis (Herbst)

Cancer bahamensis Herbst, Naturg. d. Krabben u. Krebse, II (1791), p. 30.

Petrochirus bahamensis Rathbun, Ann. Inst. Jamaica, I, no. 1 (1897), p. 42.—Benedict, Bull. U. S. Fish Comm., XX, pt. 2 1900 (1901), p. 140.

Pelican Island, from *Strombus* shell; one large male, carapace 64 mm. long, abdomen and telson together about 155 mm.

Dardanus venosus (Milne-Edwards)

Pagurus venosus Milne-Edwards, Ann. Sci. Nat., Zool., Paris, (3), X (1848), p. 61.

Pagurias insignis Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 141.

Barbados, 1 ♂.

? *Catapagurus*, species

D.S. 1, May 13; four specimens.

These specimens are all small, and somewhat broken, at least two of them may be near *Catapagurus gracilis* (Smith). The material is such that I hesitate to determine it more definitely.

A further tiny specimen without legs, from Sta. 51, Barbados, seems to be a *Pagurus*.

Family **Cœnobitidæ**

Cœnobita clypeatus (Herbst)

Cancer clypeatus Herbst, Naturg. d. Krabben u. Krebse, II (1791), p. 22, pl. 23, fig. 2A and B.

Cœnobita diogenes Rathbun, Ann. Inst. Jamaica, I, no. 1 (1897), p. 42. —Benedict (spelled *Cenobita*), Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 139.

Cœnobita clypeatus Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2, (1920), p. 329, [13].

Pelican Island, May 14; 12 ♂ 5 ♀. English Harbor; 1 ♂. Antigua, May 27; 9 ♂ 10 ♀.

Family **Hippidæ**

Hippa cubensis (Saussure)

Remipes cubensis Sussure, Rev. et. Mag. Zool. (2), IX (1857), p. 503.

Hippa cubensis Benedict, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 139.—Verrill, Trans. Conn. Acad. Sci., XIII (1908), p. 436, text figs. 53, 54.—Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2, (1920), p. 330 [14].

Beach near Pelican Island, May 27; 5 ♂ 5 ♀ ovig. Beach near Pelican Island, 3; 1 ♀ ovig. Bridgetown Beach, Barbados; 5 ♀ ovig. Bathsheba, Barbados; 1 ♀ ovig. Barbados; 1 ♀ ovig.

? *Lepidopa scutellata* Stimpson

Lepidopa scutellata Stimpson, Proc. Acad. Nat. Sci. Phila., X (1859), p. 230 [68].—Ann. Lyc. Nat. Hist., N. Y., VII (1859), p. 79 [33].—Benedict, Proc. U. S. Nat. Mus., XXVI (1903), p. 894, text fig. 6.

Sta. 42, Barbados; one larva; probably this species.

Order STOMATOPODA

Gonodactylus oerstedii Hansen

Gonodactylus oerstedii Hansen, Isopoden, Cumaceen und Stomatopoden, Ergeb. d. Plankton Exped. II (1895), p. 65, footnote.—Bigelow, Bull. U. S. Fish Comm., XX, pt. 2, 1900 (1901), p. 152, text figs. 1, 2.—Rathbun, Rapport van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door, Prof. Dr. J. Boeke, pt. 2, (1920), p. 348 [32].

D.S. 1 ,May 13; 1 ♂. D.S. 11; 1 ♂. Needham's Point, Barbados; 1 ♀. Bathsheba, Barbados; 1 ♂. Pelican Island, tide pool, May 11; 2 ♂. Pelican Island, tide pool; 3 ♀. Barbados, May 15; 1 ♂. Barbados, June 4; 1 ♀. Barbados; 2 ♀. English Harbor, 6; 1 ♂. English Harbor, Pillars of Hercules; 1 ♀. English Harbor; 1 ♀. Pillars of Hercules; 1 ♀. Pillars of Hercules, 5; 1 ♂.

Gonodactylus oerstedii var. *curacaoensis* Schmitt

Gonodactylus oerstedii var. *curacaoensis* Schmitt, Macruran, Anomuran, and Stomatopod Crustacea collected at Curaçao by Dr. C. J. van der Horst, in 1920. Bijdragen tot de Dierkunde, Amsterdam, (XXIII) (1924), p. 80.

D.S. 20; 1 juvenile. Okra Reef, Barbados, May 15; 1 ♀.

The specimen from Okra Reef carries a tiny spinule either side and a little behind the spiny-pointed distal end of the median carina of the telson.

Gonodactylus oerstedii var. *spinulosus*, new variety

Off the Castle, E. side Barbados, 1-4 fathoms; 1 ♂ 1 ♀. Okra Reef, Barbados, May 13; 1 ♀. Barbados, from coral heads, June 4; 1 ♀. English Harbor, shore; 1 ♀.

Just as *Gonodactylus chiragra* Fabricius[20], of the Pacific, forms a number of recognized varieties[21], it is reasonable to suppose that varieties would likewise be developed by its Atlantic analog as more material be-

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[20] Ent. Syst., III, pt. 1 (1793), p. 513.

[21] *Vide* Borradaile, Trans. Linn. Soc. London, (2), Zool., XII, pt. 2, (1907), p. 211.

came available for examination. It seems that this will be the case, for here we have a very distinct variety of what is specifically, unmistakable *Gonodactylus oerstedii.*

As in variety H, *affinis* de Man[22] *segregatus* Lanchester[23]) of *G. chiragra,* at the hinder end of the median keel of the telson of *G. oerstedii* var. *spinulosus,* there is present on either side, a smaller ridge almost or quite independent of the middle keel, and armed, each with two little tuberculiform spinules; one such spinule terminates the median carina posteriorly. Half way between the apex of the V of the median notch of the telson and the end of the swelling carrying the median carina, there is a small semicircular swelling, with convexity directed backward, which is often armed with four likewise tuberculiform spinules, one either side of the mid-point, and usually a second external to each of these. The bases, or anterior ends of the carinæ which terminate in the sub-median points of the telson, are broadened out proximally or swollen, in order to carry two small accessory or minor ridges, one either side of the carina proper, and armed each with a single spine at the middle, or as is sometimes the case, at the proximal end; the median of these three carinæ, or the carina proper, is armed in that portion between the minor ridges of the base with three or four spinules in a longitudinal row. Furthermore, the little lobe situated at the apex of the notch between the submedian, and the intermediate or first lateral teeth or points of the telson of the typical species, in this variety is spiniform, and moreover on the little ridge or keel with which it is provided, carries a second little spinule just above the terminal one; often too, the posterior margin of the telson carries a second spinule just external to the one just mentioned, about in line with the two or three teeth usually carried by the supplementary carina, which distinguishes the species from its Pacific relative—*G. chiragra*—in effect making the supplementary carina appear to be armed with an extra, third or fourth tooth. The submedian, or intermediate carinæ, either side of the median keel—not the accessory or minor ridges mentioned above—end in a sharp spine, as in the variety *curacaoensis,* and often as in the type behind and below this on the swelling which carries the carina, there is a second spine or spiniform tubercle in line with the first.

On the middle back of the first and fourth abdominal somites of most of the specimens are paired black markings, squarish designs looking much like some of the Chinese ideographs; in one of the two specimens in which they are not discernible they have partly faded; in none of the typical *oerstedii* did I find such markings.

This variety though it keys out as *G. festæ* Nobili[24] in Kemp's "Crus-

[22] Abh. Senck. Ges. Frankfürt, XXV (1902), p. 912; see also Borradaile *loc. cit.*

[23] Fauna Maldive and Laccadive Arch., I, pt. 4 (1903), p. 448, pl. 23, fig. 7.

[24] Boll. Mus. Torino, XVI, no. 415, 1901, p. 53.

tacea Stomatopoda of the Indo-Pacific Region''[25] seems to be distinct. From Nobili's brief description it would appear that the telson has much in common with our variety, but the shape of the rostral plate at once differentiates the two; as Nobili has it, ''in the *G. oerstedii* the external angles [of the rostral plate] are muticous, and almost flat; in *G. festæ* these angles are acute, slender, and produced forward,'' apparently, from his further remarks, much resembling *G. acutirostris* (de Man).[26]

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[25] Mem. Indian Mus., IV, no. 1 (1913) pp. 148, 153, 204.

[26] *G. chiragra* var. *acutirostris* de Man, Zool. Jahrb., Syst., X (1898), p. 695, pl. 38, fig. 77b, c. *G. acutirostris* Kemp, *op. cit.*, p. 163.

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These works by no means constitute a complete bibliography of the works cited in the text, but they do contain either in themselves, or in contained references, a comprehensive survey of the carcinological fauna of the region.

PLATES

PLATE I

Magnifications are approximate

Crangon rathbunæ, female from Okra Reef, Barbados

Fig. 1 Dorsal view of anterior portion, x about 7.5.

Fig. 2. Right, third maxilliped, x 7.

Fig. 3. Larger right chela, outer face, x about 6.5.

Fig. 4. Same, view from above, x about 6.5.

Fig. 5. Right, second leg, x 7.

Fig. 6. Same, chela, x 19.

Fig. 7. Right, third leg, x 7.

Fig. 8. Same, dactyl, x 19.

Fig. 9. Tail fan, x 12.

Fig. 10. Extremity of telson, x 62.

PLATE I

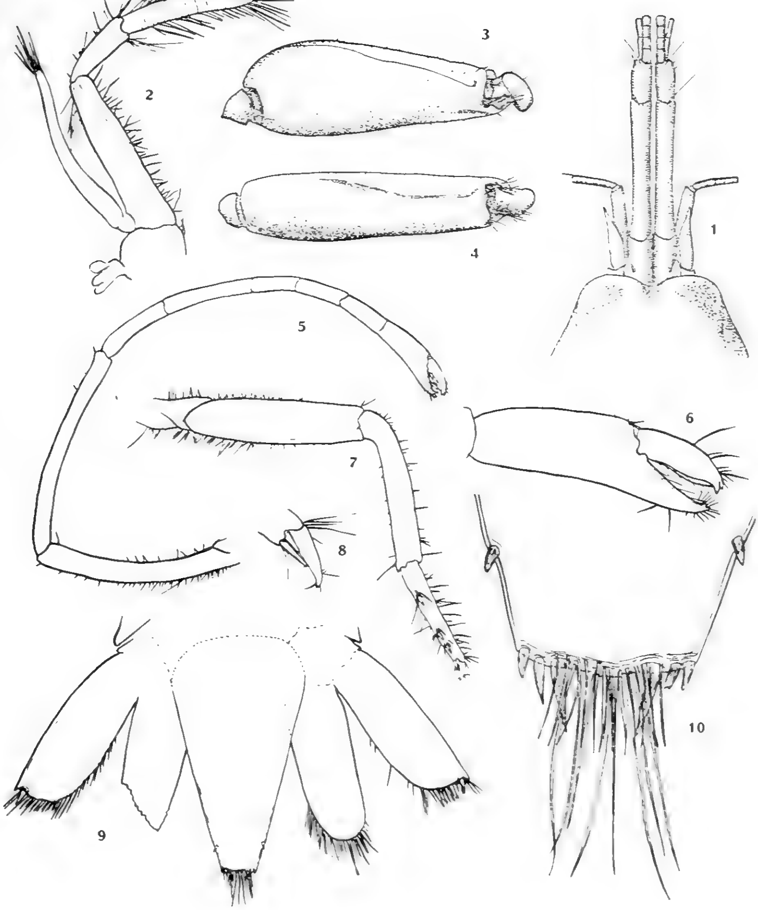


PLATE II

Magnifications are approximate

Fig. 1. *Crangon barbadensis*, male holotype, from off the Castle, E. side Barbados, 1-4 fathoms; larger, left, chela, outer face, x 2.

Fig. 2. Same, inner face of larger chela, x 2.

Fig. 3. Same, dorsal view of anterior portion, x about 5.

Fig. 4. *Crangon nuttingi*, male holotype, from Pelican Island, shallows; larger, left, chela, outer face, x 2.

Fig. 5. Same, inner face of larger chela, x 2.

Fig. 6. Same, dorsal view of anterior portion, x about 5.

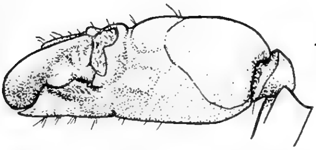
Fig. 7. *Crangon verrilli*, female holotype, in dead *Strombus* shell from Barbados, larger, right, chela, outer face, x 2.

Fig. 8. Same, larger chela inner face, x 2.

Fig. 9. Same, profile of anterior portion, x 5+.

Fig. 10. Same, dorsal view of anterior portion, x about 5.

PLATE II



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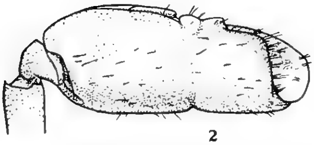

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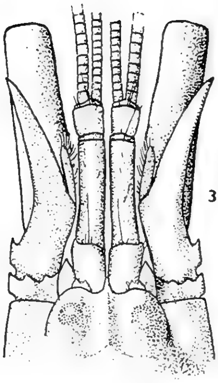

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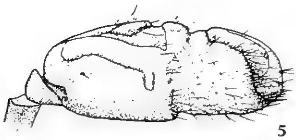

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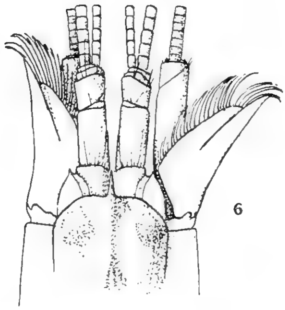

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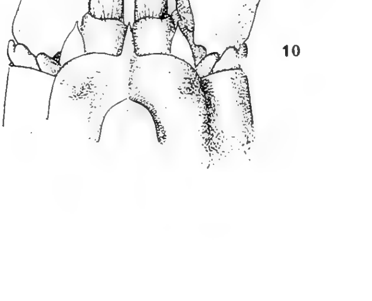

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PLATE III

Magnifications are approximate

Periclimenes barbadensis, male holotype, from English Harbor, Antigua, electric light.

Fig. 1. Lateral view of carapace and rostrum, x 7.

Fig. 2. Same, dorsal view, x 7.

Fig. 3. Right antennule from above, x 10.

Fig. 4. Right antenna, x 10.

Fig. 5. Left, first leg, x 10.

Fig. 6. Left, second leg, x 10.

Fig. 7. Left, third leg, x 10.

Fig. 8. Same, dactyl, x 65.

PLATE III

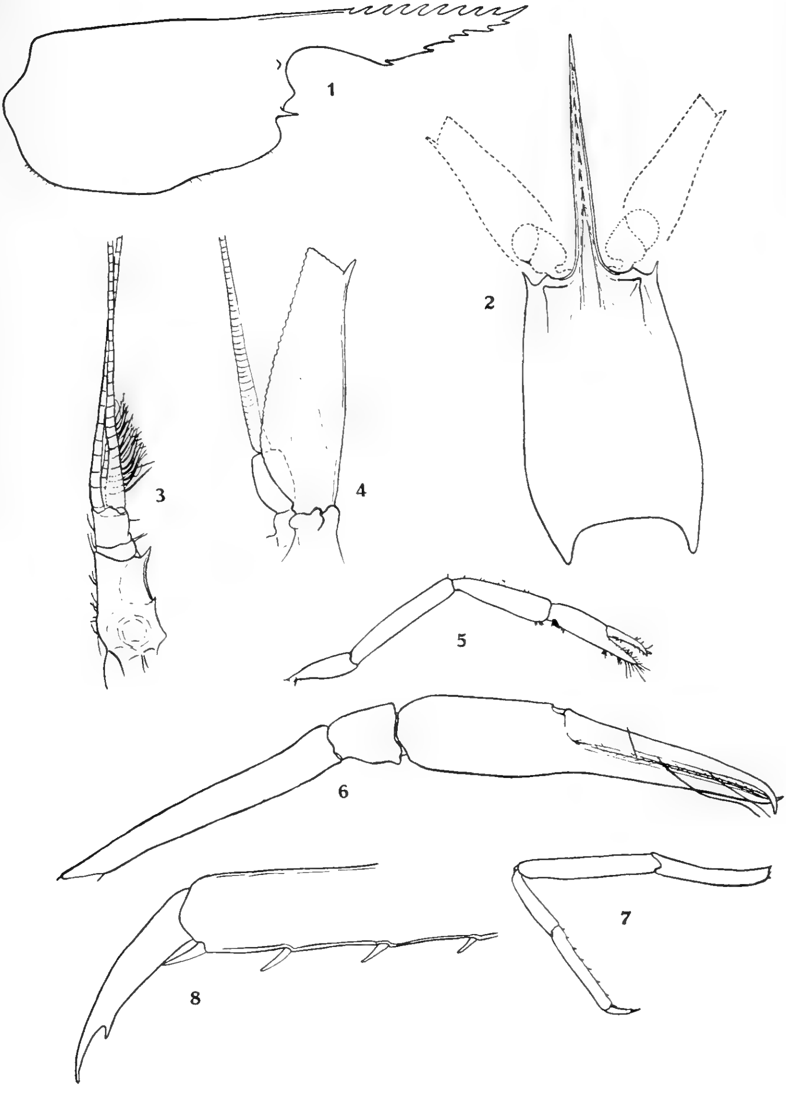


PLATE IV

Magnifications are approximate

Periclimenes barbadensis, male holotype, from English Harbor, Antigua, electric light.

Fig. 1. Right antennule, lateral aspect x 65.

Figs. 2–7. Mouth parts of left side, except fig. 4, which is right, x 34, respectively, mandible, first maxilla, second maxilla, and first, second and third maxillipeds.

PLATE IV

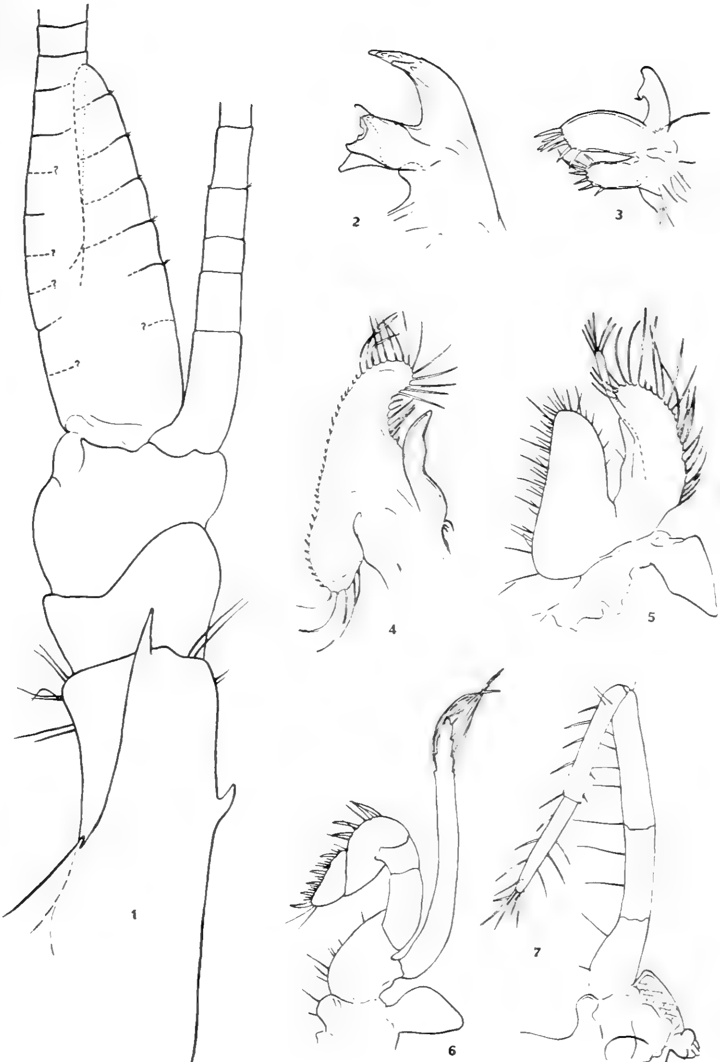


PLATE V

Magnifications are approximate

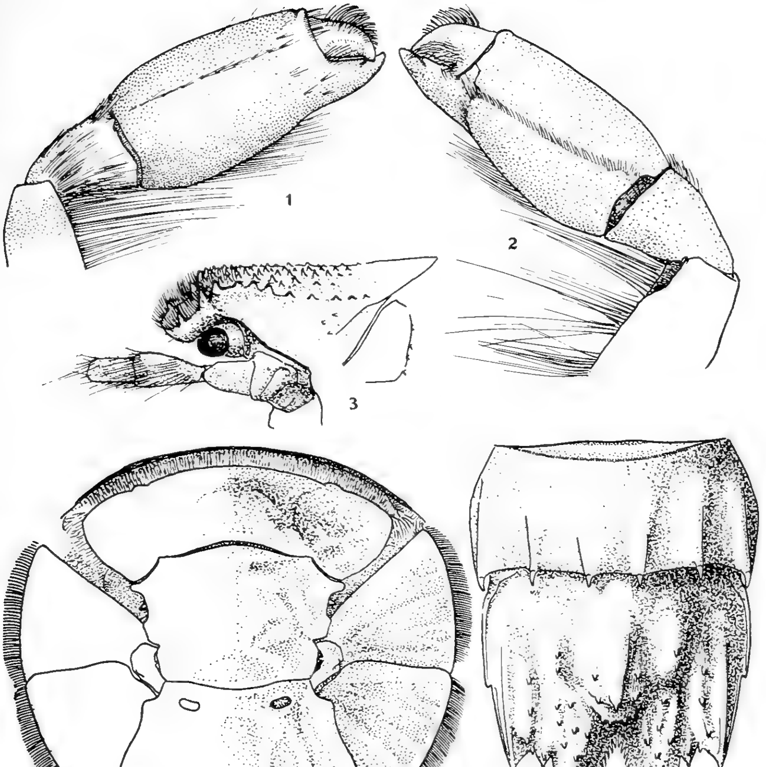
Figs. 1, 2. *Upogebia* (*Gebiopsis*) *operculata*, male holotype, from Okra Reef, Barbados. Inner and outer faces of larger, left chela, x about 7.5.

Fig. 3. Same, lateral view of anterior portion, x about 7.5.

Fig. 4. Same, fifth and sixth abdominal somites, telson and uropods, dorsal aspect, x about 7.3.

Fig. 5. *Gonodactylus oerstedii* var. *spinulosus*, female holotype, from off the Castle, East side Barbados, 1-4 fathoms, dorsal view of telson and sixth abdominal somite, x 7.5.

PLATE V



FIRST SERIES NO. 82 SEPTEMBER 1, 1924

UNIVERSITY OF IOWA STUDIES

STUDIES IN NATURAL HISTORY

VOLUME X NUMBER 5

FIJI-NEW ZEALAND EXPEDITION

by

C. C. Nutting

R. B. Wylie, A. O. Thomas, Dayton Stoner, Collaborating

PUBLISHED BY THE UNIVERSITY, IOWA CITY

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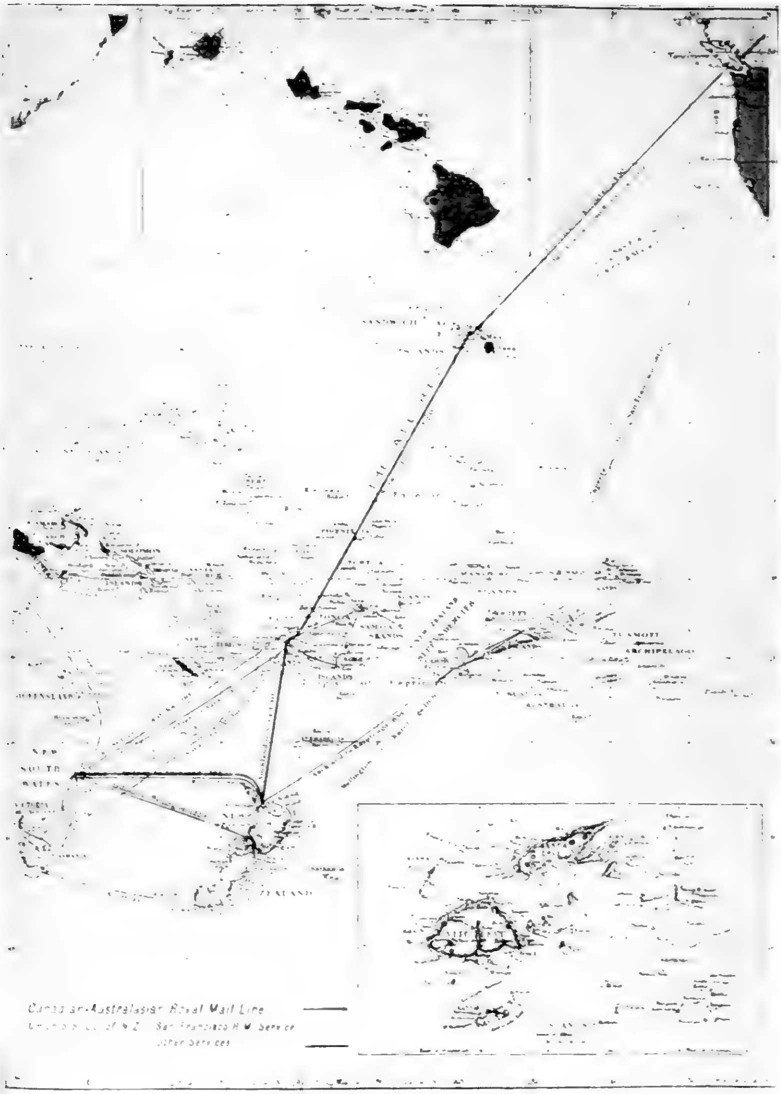


CHART OF ROUTE. Canadian-Australasian Royal Mail Line.

UNION STEAM SHIP CO OF NEW ZEALAND, Ltd. Managing Agents

Chart showing route of expedition to and from New Zealand

PLATE II

Members of the Fiji-New Zealand Party

Left to right—R. B. Wylie, Waldo Glock, C. C. Nutting, A. O. Thomas, Dayton Stoner, Mrs. Stoner

UNIVERSITY OF IOWA STUDIES IN NATURAL HISTORY

HENRY FREDERICK WICKHAM, M.S., Editor

VOLUME X NUMBER 5

FIJI-NEW ZEALAND EXPEDITION

Narrative and Preliminary Report of a Scientific Expedition from the University of Iowa to the South Seas

by

C. C. NUTTING

With Chapters on Ornithology and Entomology by Dayton Stoner, on Botany by R. B. Wylie and on Geology by A. O. Thomas

PUBLISHED BY THE UNIVERSITY, IOWA CITY

CONTENTS

PREFACE

This volume is the fourth narrative in book form of expeditions sent out in the interest of natural science from the State University of Iowa. The first of these was "Explorations in the Far North," by Frank Russell, a narrative of a trip undertaken in 1892-3 to the Barren Ground of Arctic America, the main object being to secure a series of skins and skeletons of the musk-ox which had been reported as about to be exterminated by the Esquimos to the North and the Indians to the South. The collections made by Mr. Russell were mainly zoological and ethnological and still may be regarded as among the most valued treasures of the museum.

The second was a "Narrative and Preliminary Report of the Bahama Expedition," by C. C. Nutting, published by the University in January, 1895. This relates the experiences of a party of twenty-one naturalists, mainly undergraduates from the University of Iowa, during a three months' cruise in the vicinity of the Bahama Islands, Cuba, and Key West on a sailing vessel chartered for the occasion.

The third volume of this series was the "Barbados-Antigua Expedition, Narrative and Preliminary Report of a Zoological Expedition from the University of Iowa to the Lesser Antilles under the auspices of the Graduate College," by C. C. Nutting, published in 1919. The party consisted of nineteen members, mainly zoologists, their principal objective being marine invertebrates.

The fourth narrative is the present work, which will speak for itself.

As such publications are rather unusual, perhaps unique, products of modern universities, it might be well to explain that the idea originated in my mind after reading and profiting by such works as Darwin's "Voyage of the Beagle," which always seemed to me to be of exceptional value to the naturalist, and the various narratives of Arctic and Antarctic expeditions. These works have been eagerly read by thousands whose interest in science is merely incidental and have given great pleasure and profit to specialists mainly interested in scientific objectives.

It has seemed that much of interest has been lost to the general public by the failure of those in charge of scientific explorations sent out by our universities to recognize the claims of the general public to a more popular account of such work than is given in the series of technical reports customarily issued. To meet this need of easily assimilated general knowledge for the public at large these narratives have been prepared and issued by the University of Iowa, and, if the letters of commendation received furnish a reliable criterion, the results have been distinctly worth while.

Each of these expeditions has resulted in a series of technical reports written by recognized specialists and issued as a part of the publications in the series known as "Studies in Natural History," and a number of these are still to come as it takes many years to glean the scientific results of such expeditions and to publish them in proper form.

It is proper here to express our indebtedness to the many friends who have been helpful in making a success of the Fiji-New Zealand Expedition, although these services are very generally acknowledged in the course of the following narrative.

Official aid of the most valuable kind has been given freely by President Walter A. Jessup of the University; Dean Carl E. Seashore of the Graduate College, and Professor G. W. Stewart who was Acting Dean when the preliminary plans were drawn up. We are also under obligations to Senators William S. Kenyon and Chas. A. Rawson, who obtained credentials from our Department of State and the British Ambassador at Washington.

Mr. T. J. Wall, Chicago Agent of the Canadian Pacific Railway, and his traveling assistant, Mr. Black, were indefatigable in securing concessions and favors for our party in the way of transportation by rail to Vancouver and, on the return trip, from San Francisco to Iowa City, as well as in securing the good offices of Mr. J. C. Irons, General Agent of the Canadian-Australasian Royal Mail line, who did all in his power to make us comfortable during our long sea voyage and secured permission for us to have our equipment and collections transported as baggage.

Captain J. T. Rolls of the "Niagara" and Captain B. L. Altwell on the "Tahiti" did much to make our trip comfortable while at sea. At Honolulu we were the recipients of many de-

lightful courtesies at the hands of local scientific men led by Dr. H. E. Gregory of the Bishop Museum, and my friend and former pupil, Dr. C. H. Edmondson.

At Fiji our best friend was Hon. T. E. Fell, C. M. G., Colonial Secretary, who indeed was the one who suggested the expedition to Fiji and who aided very largely in making it a success. We are also indebteded to His Excellency Sir Cecil Hunter Rodwell, K. C. M. G., for official favors; to Mr. H. C. Pilling, Assistant Colonial Secretary, for receiving our party and effects and aiding in landing, and in passing the customs house, and for other favors. Also to Mr. Harold C. Wright, Government chemist, for very efficient aid rendered our botanist and entomologist, and to Ratu Popé of Bau for hospitality extended.

In New Zealand we found so many helpful friends that it is impossible to enumerate them here; all, I believe, are mentioned in the following pages. But it is proper that acknowledgment should be made to His Excellency, The Governor General, Viscount Jellicoe, and to the Honorable William Downie Stewart Minister of Internal Affairs, for many official courtesies. Most of all are we indebted to Mr. J. Hislop, Under Secretary of Internal Affairs, and Mr. Jas. McDonald, Acting Director of the Dominion Museum. We also wish to acknowledge the hospitality of the Hon. Mr. George Malcolm Thompson and the courtesies extended by Mr. H. T. B. Drew, Publicity Officer. Among our scientific colleagues we are especially indebted to Mr. Thomas E. Cheeseman, Curator, and to Mr. C. T. Griffin, F. Z. S., Assistant Curator, both of the Auckland Museum; Dr. Charles Chilton, Rector of Canterbury College; Mr. Elsdon Best of the Dominion Museum; Professor H. B. Kirk of Victoria College; Mr. W. R. B. Oliver, F.Z.S. and Mr. Harold Hamilton of the Dominion Museum; and Mr. Gilbert Archey of Canterbury College.

Favors rendered my companions by friends in Fiji and New Zealand will be acknowledged by them in the chapters which relate their experiences while on the Expedition.

Unless otherwise indicated the illustrations in this volume are from negatives taken by the author or by Mr. Kent, University photographer, who is responsible for the frontispiece, maps, illustrations of zoological specimens, and full-page portraits.

C. C. Nutting

University of Iowa
March 10, 1924

CHAPTER I

PREPARATION

For many years I have felt the lure of the South Pacific, as indeed have most naturalists, particularly those devoted to marine zoology. In 1902 I was so fortunate as to be appointed one of the civilian naturalists on the Hawaiian cruise of the United States Steamer "Albatross," and thus made the acquaintance of the Hawaiian group, including some of its more remote members, such as Laysan Island and Necker Island; but the southernmost point reached during that cruise was only about 20° N., and the vast spaces of the South Pacific still remained unvisited.

The Barbados-Antigua expedition was undertaken and carried out in 1918[1] by a party of nineteen persons, nearly all from the University, with myself as director. This enterprise was somewhat handicapped by war conditions, although these did not really interfere with success in the field. The burden of responsibility placed upon the leader of such a party is much greater in war time than under ordinary circumstances, and like the ordinary sailor man, I vowed to myself that this would be my last voyage in any such official capacity; but the expedition was successful and all the party reached their homes in good condition, as did the very extensive collections.

When the narrative of the Barbados-Antigua Expedition was published in May 1919, a copy was sent to his Excellency T. E. Fell, C.M.G., Acting Governor of Barbados at the time of our stay there. He had been a friend indeed to the visiting naturalists from Iowa, and, one to whom we owed much of our success. Nothing was heard from him until a letter was received dated January 10, 1921, in which he explained that he had been transferred to Fiji where he had been appointed Colonial Secretary. After acknowledging receipt of the narrative and saying some pleasant things about it, he added "If you intend to organize another expedition, think of Fiji as your objective," and went on

[1] Nutting, Barbados-Antigua Expedition, narrative and preliminary report of a zoological expedition from the University of Iowa to the Lesser Antilles under the auspices of the Graduate College, 1919.

to say that we would receive the same official concessions that we did at Barbados and that it was likely that the little island of Makuluva would be placed at our disposal just as Pelican Island off the coast of Barbados had been turned over to us in 1918. He then proceeded to depict the Fiji Islands and the advantages of this group for zoological work in most alluring terms.

I was strongly tempted, but still adhered to my determination not to assume the responsibility of leadership in further adventures along such lines, and I let the matter rest until the autumn of 1921. At that time a reporter from a local paper published a note regarding the invitation from Fiji, and immediately I received an urgent request from two of the members of the Barbados-Antigua party that they be counted in on the Fiji enterprise, and asking me to act again as their leader.

This request from two of my most valued associates, Professor A. O. Thomas and Dr. Dayton Stoner, was more than I could resist, and the matter was taken into serious consideration. I found that President Jessup and Dean Seashore favored the idea, so the die was cast.

After careful consideration of the make-up of the proposed party, it was decided that membership should be limited to six professional naturalists, and that three departments of the university should be represented, botany, geology, and zoology. Such men would divide responsibility with the leader and each would be able to do more work and do it more efficiently than younger and less experienced men. Moreover, the cost of transportation, which would obviously be much greater than that of previous parties, would be very materially reduced by thus restricting the membership.

Professor R. B. Wylie, head of the department of botany, was very gladly accepted as a member and proved a most fortunate choice. We were particularly anxious to have Mr. John B. Henderson, who had done so much both financially and personally to assure the success of the previous expedition, join us; he took the matter under consideration, but was finally compelled by business and family affairs to decline with evident regret.[2]

[2] Mr. Henderson had undertaken the report on the Mollusca of the Barbados-Antigua Expedition and had the work well in hand. After our return from Fiji we were greatly shocked to hear of his death January 4, 1923, and it is difficult even now to realize that the genial, quick-witted, energetic

To the four members of the Fiji party already mentioned we added Mr. Waldo Glock, graduate student in geology, a particularily promising young man, who had already shown exceptional ability in research, and Mrs. Dayton Stoner who had accompanied her husband to Barbados and proved a very efficient collector of insects. She also agreed to attend to the commissary.

Thus we had a party made up entirely of specialists, each able to take complete responsibility for his particular field of work. There is one slight drawback, however, that seems inevitable. With six independent specialists, each full of enthusiasm for his own field of research, it is sometimes difficult to bring about the coördination, or team work, so essential to success. But the net result was good, and the scientific results, as will appear in the special reports were much more satisfactory than would have been possible with inexperienced persons, however enthusiastic and energetic.

Upon looking up the matter of transportation, through Professor Thomas, who acted as our traveling agent, we found to our surprise and gratification that our trip could be extended to New Zealand at no additional expense, so far as passenger fares were concerned; that a round trip ticket from Vancouver to Auckland, New Zealand, by way of Fiji, with stop-over privileges would cost just the same as to Fiji and return. We learned also that the Canadian-Australasian Royal Mail Line would transport us at so moderate a fare that it would cost no more to go from Iowa City to New Zealand *via* Vancouver, Honolulu, and Fiji and return to Iowa City, than one would have to pay for similar accommodations from Iowa City to England and back.

It must be confessed that we were greatly intrigued by the idea of a visit to New Zealand, that wonderland of the Antipodes. I had often indulged in day-dreams of this most ancient of all islands but without hopes of the dreams ever be-

---

Henderson is no longer with us. He was beloved by every member of the party of 1918; his wise counsel and never failing cheerfulness were the main-stay of its leader during the anxious times bound to be encountered by such a party in war-time. He also aided us very materially in a financial way, furnishing his launch, the "Eolis Jr.," with its excellently devised equipment for dredging, together with his engineer, Greenlaw, free of all charge, even for transportation and gasolene. We shall never forget Henderson nor cease to mourn his sudden and untimely death.

coming facts. Now, however, the way seemed open, and my companions were equally enthusiastic about extending our field of operations to include New Zealand as well as Fiji, and none of us had cause to regret this decision.

Of course, we already had most effective contact with Fiji in a valued and tried friend, Mr. Fell, and that was sufficient for our purpose, as we were confident that through him we could secure all available information regarding the characteristics of the Fiji group, as well as every facility that could reasonably be granted by the Colonial Government. The extension of our visit to New Zealand offered more serious problems, and it was decided that official connections with the Dominion Government would be left to myself while Professor Wylie would undertake to communicate with the scientists of New Zealand and to ascertain the best way for us to utilize the limited amount of time at our disposal.

Through President Jessup we secured letters from Secretary Hughes of the Department of State, and Senator Kenyon undertook to secure a letter from the British Ambassador at Washington to the Dominion Government of New Zealand. Previous experience had made it evident that such letters of introduction are of vital importance in the case of scientific parties. The Colonial and Dominion Governments of the British Empire so far as my experience goes, have always been alive to the importance of encouraging scientific expeditions when they are properly introduced through official channels. These governments have the power, moreover, to waive regulations regarding duties on scientific equipment, and to grant official aid to a far greater extent than seems possible for American official representatives in out-of-the-way places like our own West Indian Islands, the Virgin Islands of St. Thomas and St. Croix.[3] President Jessup also wrote a letter to Mr. A. Cecil Day, Official Secretary to his Excellency, Viscount Jellicoe, Governor General of New Zealand, stating the objectives of our visit and bespeaking the official aid of the Dominion Government. As it usually takes at least two months, sometimes three, to receive answers to letters to New Zealand, time was an element of importance and there was none to spare. Letters officially notifying the Colonial Government at Fiji of our intended visit were also sent by

[3] Narrative of Barbados-Antigua Expedition, 1919, p. 250.

President Jessup, together with the request that we be assigned quarters at Makuluva and that our effects be passed through the customs with as little delay as possible. In due time satisfactory answers were received and the coöperation of the governments of Fiji and New Zealand assured.

Professor Wylie proceeded to secure as many addresses as possible of leading scientists in zoological, botanical and geological fields now residents in New Zealand and Fiji. This was no easy task as he found the literature from these regions meagerly represented in our library. He succeeded, however, in getting in touch with a number of their leading men, and every one of them seemed glad at the prospect of a visit from the Iowa scientists and eager to afford all the assistance in his power. This enabled us to plan quite definitely regarding our objectives and the disposal of our time. Representing, as we did, three departments of science it was evidently impossible for the party to keep together while in the field, and thus we found it necessary for each to plan an independent itinerary. Manifestly the specialist in marine zoology would find it best to confine himself to the coastal regions, while Dr. Stoner, who was to attend to the birds and insects and Dr. Wylie, our botanist would do more in the interior. Professor Thomas and Mr. Glock, the geologists, would necessarily have to travel more extensively than any of the others.

The matter of itinerary thus became much more complex than in previous expeditions. We obtained valuable assistance in this matter from Mr. Fell in Fiji and also from the official chemist, Mr. Harold Wright. In New Zealand, Mr. Harold Large of Napier went to a great deal of trouble in suggesting an itinerary which would enable us to visit the more important places during the time at our disposal. We also received several maps, time-tables, railway guides, etc. from the Colonial Government which has charge of the railways in New Zealand, and these aided us considerably in working out our schedule in that country. Mr. H. T. B. Drew, publicity officer at Wellington, sent us maps and handbooks that proved particularly useful, and Mr. Clement L. Wragge kindly arranged for our reception and quarters at Auckland.

In the matter of passports, vises, etc. we were made unpleasantly aware of the fact that citizens of the United States have to pay more for such accommodations than those of other countries. It seemed that our government had established a precedent by demanding $10 for a passport and an equal amount for vises. Other governments, perhaps in retaliation, assessed similar fees from Americans, while citizens from other countries were charged only a fraction of that amount. This practice is still in vogue, and so far as I can ascertain, Americans still have to pay more for seeing the world than any other people. I suppose this is on the theory that travel is a luxury and should therefore be taxed; but it is rather hard on scientists traveling for scientific objectives and paying their expenses out of their own salaries.

An excellent suggestion came from Professor G. W. Stewart, then acting dean of the graduate college, to the effect that each member of the party prepare a list of his own objectives to be attained both in Fiji and New Zealand. We were thus led to a definiteness of aim which resulted in more clear-cut plans for work than would otherwise have been possible. It will be interesting to learn how many of these objectives were realized by each member of the party when the special reports of the expedition appear. As a matter of fact a great majority of these definite aims was attained, but we found in several instances that unexpected opportunities presented themselves while in the field, and each member felt free to switch his attention to these new and attractive possibilities, often with good results.

It was soon evident, that, lacking a generous Henderson to provide a launch and dredging equipment, we would have to give up any idea of deep sea dredging that had added so much to the scientific results of previous expeditions, and that our marine work would have to be confined to the reefs, flats and shallow water. In New Zealand, however, I was privileged to go on a cruise on an Auckland trawler that worked down to about 25 fathoms, thus securing some of the prizes in the way of marine invertebrates. The time thus spent yielded the best results, so far as these groups were concerned, of the entire trip.

The graduate college appropriated a fund of $700 for equipment and transportation of collections, and a considerable part of this was expended in the transportation of collections from our own Pacific Coast to Iowa City, for which we were compelled to pay what we considered exorbitant freight rates. These charges cut down our appropriations to such an extent that a very inadequate sum remained for equipment. We felt handicapped in this respect and as a matter of fact took with us a very poor supply of large glass jars for the preservation of the more conspicuous and showy specimens; we had to content ourselves with small bottles and metal tanks in which the specimens were crowded together, much to the detriment of the more delicate and fragile objects.

The transportation of alcohol for the preservation of material offered a serious problem on account of legal restrictions of various sorts, particularly in the United States *en route* to Vancouver. We finally arranged to have our three large metal containers shipped in bond to Vancouver, care of the S. S. "Niagara" of the Canadian Australasian line. In such matters I found it easier to deal with foreign officials than with those of our own government, with which it is hard to avoid a vexatious amount of red tape. There should be, it seems to me, some way whereby a state university might ship alcohol out of the country for the use of its own agents in a foreign land without so much trouble as at present. As a matter of fact most foreign officials, particularly the British, seem better able to appreciate scientific objectives and to make allowance for them than do our own. In short they are inclined to help any well-accredited scientific party or individual and seem well able to waive or modify their legal restrictions when the occasion seems to justify.

The form in which to take money for such a trip is important. As our operations were to be exclusively in British territory, it would seem a simple problem. We divided our funds between American Bankers Association checks and English money in the form of letters of credit. One thing can confidently be counted on, namely that the traveler always loses in the matter of exchange. We were assured by our bankers that both forms would pass at par wherever we went, but we found that we were everywhere charged exchange. English money, except small silver coins, was not current in either Fiji or New Zealand, and even bankers' checks did not pass for their par value, neither was Fiji money good, except at a discount, in New Zealand. If banking accounts were established, we had to pay for each check used in addition to the original discount for exchange. As we were responsible for the expenditure of university funds in the purchase of equipment and transportation of collections, and, as the exchange at various rates had to be carefully computed, it was no easy matter to keep our financial accounts straight. Sometimes the formality of securing receipts from native helpers, particularly in Fiji, was perplexing and their signatures weird specimens of chirography.

Having given up the idea of dredging, the devising of equipment was a comparatively easy matter. Three or four compound microscopes and an equal number of dissecting instruments met our needs, and, of course, each of us carried his own pocket lens. We intended to make much use of photography on this trip but decided to abandon the idea of taking motion pictures. On the Barbados-Antigua expedition we took a good moving picture camera and an operator with very satisfactory results, but the expense of employing an operator, paying his transportation, buying the necessary films, etc., was now too great for our slender means. The actual scientific results from motion pictures are not very great, although they are extremely popular and an aid to the popularization of scientific subjects.

We therefore contented ourselves with small cameras and good lenses, each member of the party taking the instrument most suited to his purpose and personal preference. We also took a microphotographic camera, particularly for use in making pictures of expanded living coral polyps. But that instrument came to grief before it had been of much service on account of the shutter going out of commission—one of the results of shipping a good deal of water in an awkwardly managed landing at Makuluva, where the surf was very bad.

Mr. Glock was our official photographer and did good work, using a Premo No. 12 with film packs; but he was so often separated from the rest of the party, with the exception of his fellow geologist, Professor Thomas, that he accomplished little for the zoological and botanical members. Professor Wylie was probably the most expert photographer among the biologists and his beautiful negatives of the luxurious tropical trees and plants, particularly of the wonderful tree-ferns in the interior of Fiji, would be hard to surpass and will be used in the botanical lecture rooms for years to come. He used an Eastman 3 A Special camera which took $3\frac{1}{2}''$x$5\frac{1}{2}''$ films. My own camera was an Ansco loaned by my friend and colleague, Professor Charles H. Weller, who had made good use of it in his own explorations in Greece. It took a lantern-slide-sized film and did very good service, particularly on the reefs and during my cruise on the New Zealand trawler. Professor Thomas, with his 2C Kodak, and Dr. Stoner, with a 1A Kodak, were also successful in their photographic work. Between us we brought back something like a thousand usable negatives, many of which will be utilized in illustrating the present work.

For some reason we were all inclined at first to under-expose our films, particularly in Fiji. We had been warned repeatedly that the tropical light rendered it necessary to give much shorter exposures than would be made at home. We soon found that this was incorrect and that we were most successful when we exposed about as we did in Iowa. We had little trouble from film deterioration either before or after exposure. We used Eastman "tropical" films specially packed in metal moisture-proof containers and found them quite satisfactory, although some of them entrusted to local photographers were carelessly handled and in a few cases virtually ruined. Although several of us carried tripods, we did not make much use of them, especially on the reefs, on account of the inconvenience of carrying them, along with various collecting impedimenta, into the field.

For the information of my fellow amateur photographers I will say that the Eastman films are to be had practically everywhere in New Zealand, at Suva in Fiji, and even on the steamers of the Trans-Pacific lines. There is thus little danger of getting out of photographic ammunition.

Our collecting outfit was very simple, being confined to the usual tools for shallow-water work found at all marine biological laboratories. Dr. Stoner, at the suggestion of Dr. Paul Bartsch of the U. S. National Museum, took a 410 gauge Iver Johnson shotgun, which was very light and yet shot hard enough to bring down even large sea birds. He also had an outfit for collecting and preserving birds and insects. Dr. Wylie attended to the botanical equipment and Professor Thomas to the geological outfit.

A good supply of printed labels of several sorts saved time in the field. We also secured charts of the Fiji group, especially of the vicinity of Suva Harbor, and Mr. Fell sent us a sketch map of Makaluva and vicinity. We took few books, but included Alexander Agassiz' "Reefs of Fiji" and Dr. Wayland Vaughan's "Corals of Laysan Island." Dr. Vaughan very kindly gave me the method that he had found most successful in killing coral polyps in an expanded condition. A few entomological, botanical and geological books and pamphlets were also included. In the matter of commissary we decided to depend almost entirely on what could be found in the localities visited and made no mistake in so doing. We did, however, on the advice of the University dietitian, Professor Ruth Wheeler, take along a supply of milk powder called "klim" and found it very satisfactory at Makuluva where we should otherwise have had difficulty in securing milk of any sort. A small medicine chest with contents suggested by Dr. C. P. Howard of our college of medicine was included in our outfit. The military department of the University very kindly provided first aid kits for each of us. Fortunately, however, we had little occasion to resort to either, as we were all in good health during our stay at Fiji, and well equipped physicians were available in New Zealand.

I have found from experience on various expeditions, mostly in tropical regions, that the life of a normally healthy man or woman engaged in field work is about as safe, so far as health is concerned, as it is at home. Among the forty-five persons forming the make-up of the parties to the Bahamas, Barbados and Antigua, and to Fiji and New Zealand, there was remarkably little ill health of any kind; no more, indeed, than would likely have been experienced during similar periods in Iowa. A few mild cases of indigestion and slight fevers due to prolonged exposure to the tropical sun are about all that I recall, and in these cases recovery was quick and complete. An out-of-door life, good plain food and regular habits can ordinarily be depended upon to maintain at least average good health.

In the matter of clothing we were confronted with the fact that we would be in a tropical country while at Fiji and in a winter climate during our stay in New Zealand. A complete outfit for both summer and winter had to be provided for each person; also mosquito netting, water-proof blankets and a small kit for camping purposes, particularly in Fiji. We found many useful contrivances at reasonable prices at an "army store" in Iowa City.

Here, also, several of us secured good field glasses at low cost, although they were actually used less than might have been anticipated.

With all these matters to attend we found plenty to occupy our attention during the period of preparation, and it must be remembered that each of us was carrying on all of the ordinary activities that fall to the lot of the university teacher. Professor Thomas had many letters to write in attending to the matter of transportation of our party and its equipment, but the arrangements made by Mr. Black, of the Chicago office of the C. P. Railway, and Mr. Wall, his immediate superior, were in the end thoroughly satisfactory, and we secured very good quarters on the S. S. "Niagara" of the Canadian Australasian line at the minimum rate.

The work of packing our outfit was supervised by Dr. Stoner with his usual efficiency. We did not realize at that time the extent to which our party would be scattered while in the field and later found considerable difficulty in separating the material required by each, especially when we arrived at Makuluva. In future, this might be avoided by packing the material required for each individual in separate boxes, so far as is practicable. This also has its disadvantages and is less economical of space than the plan which was adopted for this trip.

Personal luggage was packed in steamer trunks, one for each member. We found some "officers' trunks" at the army store that were well made, cheap and admirably adapted to our purpose. Duplicate lists of all materials were made as the packing progressed; the boxes were listed by number and the contents of each specified in detail. As all packages were to go as baggage their weights had to be ascertained and kept below the maximum allowed for personal luggage, and each trunk or box provided with good iron handles for the convenience of baggage-men.

As a matter of fact the only serious mistake was in using too light material, galvanized iron, in the square tanks for specimens in alcohol or formalin. These were enclosed in good wooden boxes, heavy enough, we thought, to insure them against injury. We found, however, that several of the tanks developed serious leaks when we returned from Makuluva and after we reached New Zealand they had to be patched up under circumstances involving considerable annoyance and inconvenience. There was little damage to material, however, and our collections arrived in good shape. But it is manifest that copper tanks such as are used by the Bureau of Fisheries are the best and safest. For the smaller things preserved in fluid we used square bottles packed in the chest devised by Dr. Paul Bartsch of the National Museum. Each chest contained 108 bottles. We also took along a number of the square tin pans described in my narrative of the Bahama Expedition and found them very useful for laboratory purposes such as sorting and killing specimens.

Because the party was smaller than on previous occasions, and because of the omission of dredging equipment and large glass containers, we found the number of packages reduced to twenty-two and the weight to 1915 pounds. This was exclusive of three twelve gallon drums, containing alcohol, which were sent by express. We were allowed 350 pounds per person, or 2100 pounds in all, on our railroad tickets which were accompanied by an equal number of Trans-Pacific tickets. In this way our entire equipment was transported from Iowa City to Fiji, and later to New Zealand, free of charge. Coming back was another story, so far as railroad transportation was concerned, as will appear later.

The time from September, 1921, to May, 1922, was none too long to attend to the details of preparation, innumerable details it seemed to us. Indeed, much more time could have been used to advantage, and my experience goes to show that a full year should be allowed to actually attend to the preliminary arrangements for such an expedition.

We left Iowa City on the evening of May 14. At 5:30 in the morning of Tuesday, May 16, we reached Portal, on the Canadian border, and saw our equipment and personal luggage, except hand luggage, bonded through to Vancouver.

Wednesday, May 17, was a glorious, bright day in the Canadian Rockies. There was more snow on the mountains, through which the Canadian Pacific wends its way coastwards, than I had ever seen there before, and the great white masses stood out sharply against the intense blue of the sky. Most of our party tried out their cameras with satisfactory results, but I refrained until after we left Vancouver which I regarded as our real point of departure. At times the road ran above the snow line and the temperature fell to a wintry chill. Although the Canadian Pacific Railroad route is familiar to me, there is always a thrill in the stupendous scenery of majestic mountains, and many a new picture was hung on memory's walls that day.

The next morning found us gliding through the brilliant green Columbian country, partly shrouded in fog and rain, with occasional bursts of sunshine, but the day settled fair and clear before we reached Vancouver, one of the loveliest cities on the Pacific Coast, where our agent had secured comfortable quarters for us at the hotel St. Regis.

After breakfast we went at once to the office of the Canadian Australasian Royal Mail Line, noting in passing that the "Niagara" was at her dock. Mr. J. C. Irons, General Manager of the line, had made very satisfactory arrangements for our comfort. He personally conducted us to the ship, introduced us to the captain and showed us the staterooms that were to be our home until we reached Fiji. In the afternoon we enjoyed a visit to Stanley Park, with its superb display of big trees, mostly Douglas firs, that remind one of the pillars of some great cathedral. The evening was spent in writing last letters to our families and friends and also to university authorities explaining a change of plans regarding our return voyage. There is always an oppressive sadness on the evening before sailing that does not lessen as the years go by. Indeed, it is to me the most trying time of any voyage and always dreaded more than the actual sailing day, which is attended with sufficient excitement to crowd out the thoughts that otherwise would be saddening. I wished more than once that the evening before sailing could be abolished entirely.

As the "Niagara" would not sail until near midnight, we still had a day at our disposal. Mr. Irons had posted us at the Vancouver Club and some of us took lunch there. The club house is one of the finest that I have seen, commanding a superb view over the bay and its shipping, and the service is excellent. That afternoon Thomas and Stoner went down to attend to the transfer of our luggage to the dock and check up on the packages, all of which were accounted for and, apparently, in good condition.

The wharf on "steamer day" is always interesting, and one is impressed with the enormous capacity of a great liner as the huge piles of merchandise are stowed away with efficiency and dispatch. Most of the freight was billed to Sydney, Australia, and we were particularly struck with the number of automobiles that were being sent out. There were sixty Buicks and many Fords and Dodges, the three makes seeming to be the most popular ones in Australia. The busy scene always has its fascination; the rush of the trucks, the shouts of the stevedores, the clank of the hoisting engines, and above all, the efficient coördination amid the seeming confusion intrigues the imagination as the great steamer gradually sinks to the loading line.

CHAPTER II

OUTWARD BOUND

We boarded the "Niagara" at 7:30 on the evening of May 19 in order to get settled in our state rooms before sailing. We were allotted three comfortable staterooms, with ample space for our luggage and ourselves. A state room in a modern liner is a marvel of compactness and convenience. There was a small wardrobe for each of us, separate wash basins, a place to hang our watches where they would be safe and easily reached, pigeon holes of various sorts for toilet articles, several small drawers, electric lights, call bells, electric fan and a full length mirror on the door. It was evident that we were to be comfortable on our voyage of 5215 miles to Fiji.

In the morning we found the ship tied up to the dock at Victoria, Vancouver Island. At breakfast we made a party of eight, including six Iowans and two ladies we met on the train coming from St. Paul to Vancouver. We had time for a stroll ashore and saw something of the city of Victoria, the capital of British Columbia, with its beautiful and stately public buildings. The day was clear and quite chilly and the snow capped Olympic Mountains stood out against the clear blue sky in the distance.

We passed out of the straits about 6:00 P.M. and then headed directly for Honolulu, our first port of call, after which we took coffee in the lounge and smoking rooms, both of which were commodious, and comfortably furnished with small tables, capacious chairs and divans, where men and women could meet socially and become acquainted. The brilliantly lighted saloons, state rooms and decks afforded a most agreeable contrast to the state of affairs when we were last at sea which was during war time when all was gloom after night settled down and not a flicker of light visible on deck. At that time it was a crime to strike a match and the man with a lighted cigar was promptly squelched. Thus the roomy brightly lighted decks of the "Niagara" were symbolic to us of the vast difference between war and peace, and we felt a sense of security that had been lacking during the voyage to and from the West Indies in 1918.

It was quite rough when Thomas and I went on deck for an airing before retiring, and I found the warmth of the berth quite a comfort. There was considerable motion to the "Niagara" which we nicknamed "Rolls," after the captain, and when I went on deck the next morning Glock was the only other member of our party in evidence; even he seemed disinclined to indulge in breakfast. So I was the only occupant of our table, and the dining saloon as a whole was very thinly populated. Sea-sickness is an ailment that I could never understand, lacking personal experience. It certainly has little to do with the general health of the individual, the most robust persons often suffering severely while many apparent invalids are immune. Wylie's attack was brief but orthodox. Stoner seemed the most afflicted, while the others were soon up and about. My own considerable experience at sea has shown that the less I intrude myself on others the better. So I busied myself with writing in the library.

It was a bright day with considerable sea running. The first day at sea always has a strong fascination and I never get over the joy of it, but feel selfish to be so content when others are manifestly unhappy. It was still too chilly for comfort on deck and it was almost as bad below, the ship being insufficiently heated, as are all British vessels, from the American point of view. The dining saloon was extremely cold with all the ports open. Later, the smoking room was heated, at least according to the British idea of comfort. The next day the sea was smoother and the air slightly warmer.

A sybarite life, this! The steward brought coffee, crackers and fruit at 7:30 A.M. to sustain life while dressing. Then the bath room steward announced, "Your bawth is ready, sir." After a warm plunge in an exceedingly deep bath-tub I was joined at breakfast by all but two of the party. Thomas and Glock enjoyed deck tennis later and all were much happier while the life on board ship livened appreciably. Captain Rolls told of an experience he once had when the "Niagara" ran square into a sleeping whale in mid-Pacific. It was just beneath the surface and the vessel's stem struck it near its middle where it hung, cut about half in two, until the engines were reversed and the ship backed away. The whale was killed by the impact.

A ship is always full of interest. While the oldfashioned full-rigged vessels were, undoubtedly, the most picturesque and beautiful craft that ever floated, there is majesty about a modern liner.

Although it was quite rough I accepted the invitation of the chief engineer, Mr. Petterson, to inspect his domain, and received permission to have Mr. Glock accompany us. There is probably no aggregation of mechanical devices more complex and compact than that of a modern steamer. There are scores of separate engines, arranged with the greatest possible economy of space and fitted together with the nicety of the parts of a watch. There are pumping engines, compressors, condensing engines, fans, injectors, dynamos for oil, steam, water and gas; hydraulic engines for hoisting. Electrical power is used in many ways and there is a great switchboard for its instant control. Immense turbines actuate the triple screws. Away down, far below the level of the sea, are the three great shafts, each 17½ inches in diameter and working independently. There is power everywhere, throb and hum and constant bewildering motion. A powerful fire engine is there ready for instant service in case of need. The floors and hand-rails are slippery with oil, the narrow steel stairways and ladders lead more and more deeply into the bowels of the ship. The vessel is rolling and staggering in the heavy seas and one has to watch his steps carefully to avoid going headlong into the titanic mass of steel, moving smoothly and quietly for the most part and with grim, irresistible power.

Below the engines are immense furnaces for burning crude oil which is fed by blasts which spray the oil in the form of a fine mist, and the heat of from 2,000 to 3,000 degrees is constantly maintained. Over 30,000 barrels are burned during each round trip from Vancouver to Australia and back.

We were surprised to see so few men working among the engines, boilers and furnaces. Hardly more than a half dozen were noted during our trip of inspection, and Chief Petterson said that by using oil burning furnaces, the labor of at least fifty stokers was saved as well as much space and time for re-fueling. There is also much less dirt and it is claimed that there is less danger from fire than when coal fuel is used. The oil bunkers are easily filled and easily trimmed, that is, the weight equally distributed on both sides of the vessel. We even peered into the shaft tunnel just above the keel of the ship. The chief explained the various engines, furnaces, etc. very carefully, but the information was more than we could digest all at once and we emerged into the upper world with a feeling of bewilderment, although we did retain a good deal of information that was new and most interesting.

The sea was again "lumpy" and the party not so happy. The ship rolled a good deal in spite of her size and beam, and it was chilly everywhere, about the only comfortable place being our bunks or the smoking room, and the latter was not at all attractive to those inclined to sea sickness.

May 24th was "Empire Day" and when we asked the captain for permission to decorate our table with British and American flags he offered to have it done. On going down to dinner we found all of the tables and the walls of the dining saloon gay with flags of various nations. Our table had a big American flag in the middle and groups of British, American, Australian, Canadian and New Zealand flags at the ends. We appeared in full dress for the occasion while the other male passengers contented themselves with tuxedos. There was dancing on deck in the evening, although achieved with some difficulty owing to the lumpy seas.

The next day was my birthday and I opened the little packages stowed away in my suitcase by the dear ones at home, who had given instructions not to "peek" until May 25th; their remembrances brightened the day which would otherwise have been a rather gloomy one, in fact a homesick one. At dinner, however, a grand surprise awaited me, the result of a conspiracy of our party, including the "adopted ladies," Miss Hutton and Miss Fanning. I imagine that the Stoners and Thomas, old and tried companions of a previous expedition, were the chief conspirators, aided and abetted by all the others.

The table was profusely decorated with red, white and blue stripes along the middle of the white cloth, and three groups of little flags made bright the ends and center, the largest flag being "old glory" which never seems more beautiful than when one is far from home. There was an Iowa pennant at one end and a "Niagara" pennant at the other. I was so dazed and touched by this great kindness that I did not at first see a real surprise planned by the chief steward. At the top of each menu card was printed "Wishing Mr. C. C. Nutting many happy returns of the day." One of these menus signed by all of our party and the two women is one of my most valued reminders of the trip. The steward presented each one of us with a similar card in an envelope ready for mailing to the home folks. But the recipient of all these honors was to be still more completely overwhelmed when a huge birthday cake with most elaborate devices in the way of frosting after designs by the pastry cook was brought in by the steward. The top was ornamented with little silvery beads and in pink letters the inscription "Many happy returns 25-5-22." The huge cake would have sufficed for several times the number at our table and it was passed around to the captain's table, and pieces reserved for the chief engineer, chief steward and our waiters who outdid themselves in entering into the spirit of the occasion. It must be confessed that I was touched beyond power of expression and I could not fail to recall a similar occasion on Pelican Island in 1918 which was instigated largely by the same dear friends and companions.

Early in the morning of May 27th we found ourselves approaching Oahu, one of the most beautiful of the Hawaiian group, and in sight of Diamond Head, a landmark well known to all who have visited Honolulu. The rugged summits of the high purple mountains cut the sky line with jagged serrations and the vividly green valleys dappled with shadows of clouds, the breakers dashing upon the beach with its fringe of palms and low bungalow-like houses, the curve of the harbor with its entrance between rows of gleaming white rollers were all familiar enough to me. Just twenty years ago almost to a day, while serving as a civilian naturalist on the U. S. S. "Albatross," I had visited the Hawaiian Islands. But the city of Honolulu had changed so greatly as hardly to be recognizable. Immense steel and cement warehouses crowded the water front and stately buildings behind them almost hid the Palace and Judicial building which, in 1902, were the most conspicuous structures to be seen when approaching from the sea. Great hotels and business houses gave a metropolitan air entirely lacking at that time. Electric trolley cars had taken the place of the mule-drawn trams and hundreds of autos dashed through the streets where buggies, carriages and horses had been the only modes of transportation.

After inspection by the health officers and a hurried breakfast, we went on the deck where we were received by my friend and former pupil, Dr. C. H. Edmondson, who was accompanied by Dr. Gregory, director of the Bishop Museum, Dr. Lyon, director of a privately endowed experiment station, Dr. J. M. Westgate, director of the United States Experiment Station, Dr. Kunkel, pathologist of the same institution, Dr. Bergman, professor of botany in the University of Hawaii, Mr. Judd, chairman of the Board of Trustees of the Bishop Museum, Dr. Hall, also of the Museum, and several other scientific men with their wives.

These good friends proceeded to give us such a day in Honolulu and vicinity as none of us will ever forget. They put us into autos for a delightful drive to Pali Pass, a scene of mountains, valleys and sea that is noted throughout the world. I could not help contrasting this swift ride over the best of roads of easy gradient with the painful ascent for wearisome hours on the occasion of my former visit. Winding through fields and forests of tropical trees, strange forms of vegetation on either hand, catching enchanting vistas of the city and the blue Pacific as we looked backward and of deep valleys and rugged crests of mountains as we looked ahead, we finally, with almost startling abruptness, found ourselves at the top of the Pass where we left the cars to view a picture too sublime for description. We stood on the bank of a sheer precipice over which tradition says a whole army was pushed by a victorious host. We could see the road winding down the other side like a white ribbon, and the exquisite green of growing sugarcane. There were scattered groups of coconut palms, beyond gleamed the breakers of the Pacific as they lazily rolled over the coral reefs on the windward side of Oahu. Then the deep pure blue of the ocean, appearing deeper and purer than ever when viewed from this height.

We then visited the magnificent botanical garden connected with the experiment station under the direction of Dr. Lyon, who was our guide. For two of our party this was the first view of real tropical vegetation, and no better introduction to its marvels could be found. Next we went to the Club for luncheon with a notable group of Hawaiian men of science, many of whom had already welcomed us at the dock. We had broiled lobster and "poi," the most characteristic native dish tasting and looking much like a paper-hanger's paste, but we ate it with our spoons instead of swiping it into a gluey mass on two fingers as is, or was, the proper custom. There were delicious strawberries and watermelons, topped off with coffee and excellent cigars for those addicted to the weed. After luncheon I was called on to explain why we were there and tell "what we had up our sleeves." They seemed interested in our expedition, as was natural when we remember that Hawaii is the center of scientific activity for the whole of the tropical Pacific.

After lunch we were whirled away to Waikiki Beach, the Coney Island of Honolulu, past gigantic hotels that have been erected since my former visit, and to the aquarium and marine laboratory in charge of Dr. Edmondson, in which we were particularly interested. The aquarium is a great popular attraction where many curious and wonderfully colored fishes are well exhibited to thousands of visitors, mainly tourists, who visit the beach. There are "butterfly fishes," gorgeous fellows displaying their "homeward bound pennants" in the form of very greatly attenuated dorsal fins; blue "unicorn fishes," "angel fishes," morays, "devil fishes" and many others. A better place for an aquarium could hardly be found. Immediately in front of it are the coral reefs with their innumerable brilliantly colored fishes and other animal forms.

Edmondson's marine laboratory is very conveniently located right on the beach at Waikiki with good coral reefs but a stone's throw away, and with convenient tables for investigators and students from the University of Hawaii. He is indeed fortunate with a rich tropical fauna at his very door and the inspiration of students in his daily work at the University of Hawaii.

Next we visited the famous Bishop Museum under the direction of Dr. Gregory. The collection embraces priceless treasures in the way of ethnological material, and many of the zoological specimens are unique, especially some Hawaiian birds, a large number of which are now practically extinct. The mounted fishes were particularly attractive in their gorgeous colors and bizarre forms. It is one of the best exhibits of fishes that I have seen. Of course, we were greatly interested in the reef fauna of the tropical Pacific including many exquisitely beautiful corals. This museum occupies a strategic position as a central point for the study of the fauna of the Pacific, of easy access to many of the island groups of Oceanica with their fast vanishing people and fauna. A comprehensive survey is under way and the Bishop museum is in a position to be greatly benefitted and to become one of the most important in the world at no distant day. Its connection, through Dr. Gregory, with Yale University is also fortunate. From him I obtained helpful letters of introduction to the scientists of Fiji and New Zealand.

I was much interested in what Dr. Gregory had to say about the Japanese and other inhabitants of the Hawaiian Islands. He stated that the Japanese, and particularly the younger generation, were improving in their loyalty to the United States, for most of them were born and brought up under the American flag; on the other hand the older men still felt attachment to their mother country, Japan, and believed that their loyalty was primarily due to her. Dr. Gregory believed that those of the younger generation were entirely sincere in their attachment to the United States and said that they had an organization for the express purpose of fostering this loyalty. He regarded the Portuguese as the most troublesome element in the population; many of them have been brought in as laborers on the plantations, and do not amalgamate with the other races.

I could not help thinking of an incident that occurred during my former visit to the Island of Kaui. We passed a native hut whose occupants had allowed a family of Portuguese to camp in their door yard. A few weeks afterward we passed the place again and saw that the Portuguese were occupying the house while the natives were camped out in the yard.

There is an interesting parallelism between the bird and human populations in Oahu. The pestiferous English sparrow from America and the equally aggressive "minah birds" from India had almost driven out the native Hawaiian birds from a large part of the island. A similar disaster is under way regarding the native people. The whites from Europe and the United States, and the Chinese and Japanese from the Orient have met here in mid Pacific where the fine and really generous Hawaiians seem doomed to extinction between the upper and nether millstones of superior civilizations.

A number of our scientific friends accompanied us down to the dock and, after the beautiful Hawaiian custom, bedecked us with exquisite "leis" or necklaces of brilliant flowers in such profusion that we were fairly eclipsed. Thus ended a day that none of us is likely to forget and we boarded the "Niagara" impressed and immensely pleased with the unbounded kindness and lavish hospitality of our friends of Honolulu.

We passed out of the harbor as the sun was low on the horizon and gazed somewhat wistfully on the jagged purple hills of one of the most beautiful of all tropical islands. The Southern Cross came out in the velvety blackness of the swiftly enfolding night and we thought that the last link that bound us to the land we loved had been severed, that henceforth we would meet with strangers only, with the sole exception of our good friend, Colonial Secretary Fell, of Fiji.

When we went down to dinner a transformation had occurred that showed that we were in the tropics at last. The officers and stewards had changed from blue uniforms to white and the easy chairs and couches in the lounge had also been transformed with light colored covers.

I found a letter in my state room from Secretary Fell informing us of preparations for our comfort there; I was glad to learn that the Government had consented to turn over the island of Makuluva for our use and that the coral reefs in that vicinity were alive and flourishing.

A letter received before we left Iowa from my friend, Dr. Alfred G. Mayor, who had visited Suva in 1920, had given me the impression that many of the reefs around Fiji were in poor condition from a biological standpoint, and he intimated that we might have to hunt for living reefs suitable to our purpose. When I received that letter I little knew that Dr. Mayor, who worked with me many years ago at Alexander Agassiz's laboratory at Newport, was to die in a comparatively short time after writing me regarding Fiji. We learned of his death shortly after our return. He was one of the most delightful companions that I have known, and I have often watched him as he made his wonderfully life-like plates of medusæ and other delicate marine organisms that he limned so skilfully, and wondered at his unsurpassed mastery of pencil and brush. With his passing America lost one of its most accomplished marine zoologists.

On leaving Honolulu we started on another long leg of our journey. The first one, from Vancouver to Honolulu, was 2,435 miles; and the second one, Honolulu to Fiji, was a little longer, 2,780 miles. We were now well within the tropics and could enjoy the life on deck. The sea was beautifully calm and the heat not at all oppressive as we resumed the daily routine of life on a long voyage.

We saw but a single vessel, except in and near Honolulu, after leaving Victoria, indeed the Pacific is a vast lonely sea, singularly devoid of living things on or above the surface. A couple of black-footed albatrosses followed us a day or two after leaving the American coast, but very few other birds were in evidence. Even the gulls so familiar to voyagers on the Atlantic were conspicuous by their absence, and for days at a time not a living thing was seen over the heaving expanse of waters. A few schools of flying fish occasionally broke from the surface and fluttered along just skimming the crests of the waves for a few hundred feet to dive again, but they were by no means so abundant as in the tropical Atlantic, particularly near Barbados where they are so plentiful as to be one of the most abundant and highly prized market fish. At night hardly a gleam of phosphorescence was seen as we bent over the rail and watched the rush of the passing waters. The loneliness of the vast stretches of the Pacific impressed us strongly throughout our entire trip.

The weather was decidedly warm, but not uncomfortably so. Light summer underclothes were donned and outing suits were in evidence; white duck seemed to be the proper thing, and the clothes purchased for the Hawaiian cruise of the "Albatross" twenty years ago were again in service. Deck sports served to pass the time pleasantly for most of us. The British are inveterate sportsmen the world over and a "Sports Committee" is chosen on every voyage to manage the various tournaments. Seasickness seemed a thing of the past and everyone on board appeared to be enjoying life with zest.

Although we were nearing the equator and the temperature was quite high, the cool breeze kept up, aided at night by electric fans, so we did not suffer.

The Iowa group held conferences from time to time regarding the plan of operations in Fiji. We agreed to divide our party during our stay on the island of Vitilevu, some of us staying in or near Suva for the land work, but all taking turns at the reef work on Makuluva, the little island that the Colonial Government had set apart for our use.

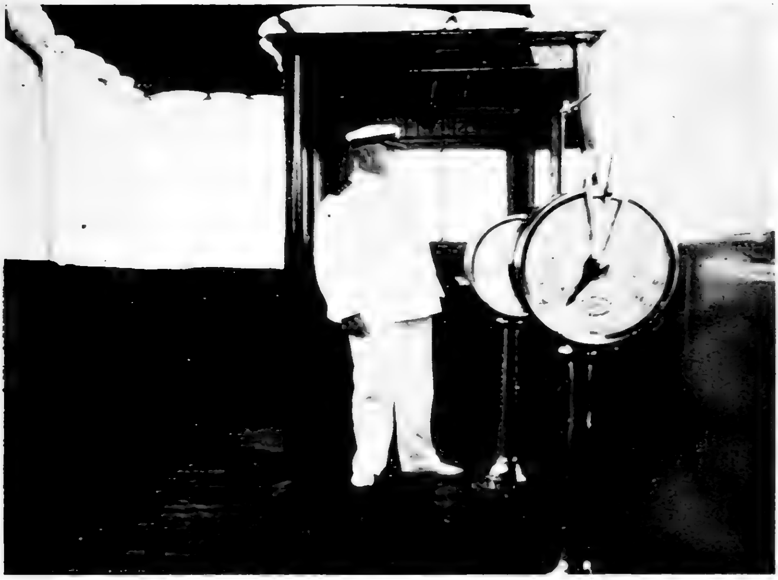
We were now further south than any of us had ever been before. The North Star was about to disappear and the Southern Cross was nightly higher in the heavens and more and more conspicuous. The horizon was daily bedecked with "tropic clouds," and the sunsets were gorgeous beyond description. The clear blue of the ocean was flecked with white caps, while the sudden rain squalls came, drenched the decks, and were gone again in a few minutes.

On the 31st of May we passed the only vessel seen on the entire outward-bound voyage. It was the "Makura," the companion ship to the "Niagara," and the one in which we expected to go from Fiji to New Zealand on her return voyage from Vancouver. A few seabirds were sighted which seemed to indicate the proximity of land, although we had sighted none since leaving Hawaiian waters on the 28th.

We crossed the equator at 3:45 P.M. and the next morning before day-break we passed some islands, probably outliers of the Fiji group, where the increasing number of sea birds indicated the proximity of land. A lady, Mrs. Crompton, and her daughter, residents of Suva, had given us a good deal of information about Fiji. She considered us fortunate in knowing Secretary Fell as he was one of the most powerful men in the Islands and his friendship would assure every consideration as well as governmental aid. They also gave us considerable information about the little island of Makuluva which was to be our home for some time. That day I sent a wireless to Colonial Secretary Fell announcing the expected arrival of our party on Monday.

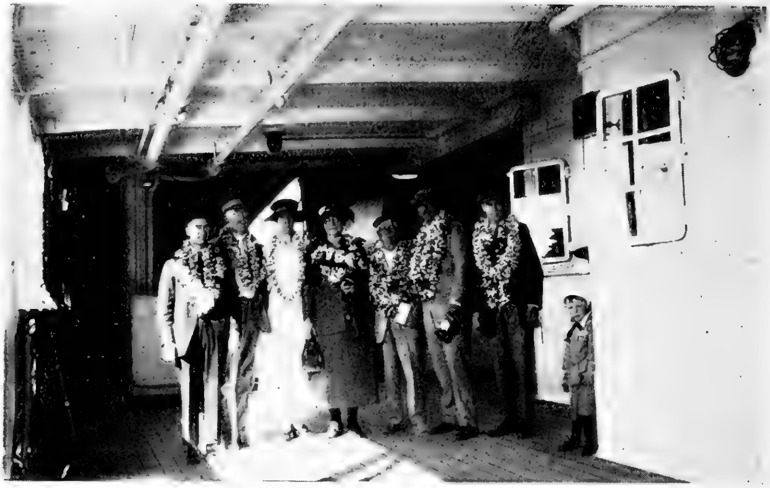
In the afternoon the captain told me that there was to be a boat drill and suggested that I photograph the scene from the bridge. He posted me where I could get the whole range of boats on one side. Unlike the procedure in war time, the passengers took no part in this drill and were not notified when it was to take place. All the boat's crew assembled and stood in their places at the sound of the whistle. They were inspected by their officers and the boats swung outward by a new device in the way of patent davits so contrived that one man, by turning a crank, can swing a heavy life-boat out-board, the davits turning on their axes and also moving outward bodily so that the boat still attached to the davits swings out clear of the rail. A reversal of the process swings them in-board again. The whole thing worked with mechanical precision, but it is by no means certain that this would be true if the ship had to be abandoned on a wild night or in case of a rapidly spreading fire. The scene was quite imposing and I secured a good negative; also one of the captain on the bridge.

That evening we had a masked ball which gave rise to much hilarity. During the previous part of the voyage we had noticed an exceedingly dignified gentleman from Calgary, partly bald and unapproachable, except by the socially elect. When the maskers came to the dining saloon there appeared a portly Hawaiian beauty with long bushy hair, short grass skirt, bare feet and legs and the golden brown complexion, including feet, of the sunkissed natives of Oahu. This was the ultra dignified man from Calgary, and a greater transformation I never saw. She smiled and simpered, showing charming dimples and extreme embarrassment in the presence of so many white folks, and the novel etiquette at the dining table. She won first prize by acclamation! There



Captain Rolls of the "Niagara" (See page 23)
The "Niagara" at her dock at Victoria, B. C. (See page 22)

PLATE IV



The party leaving Honolulu bedecked with "leis" (See page 29)
Inner Harbor of Suva, Fiji (See page 33) (Photo by Thomas)

was also a bridal party, a live doll excellently gotten up, a Hindu woman, some Fijians, Chinese, Negroes, etc. The procession on deck was quite imposing and the dance which followed made a brilliant finale. One would not have supposed that the material for so many excellently devised costumes could be found on board ship.

The next morning I received a long wireless from Secretary Fell saying that he could secure a good launch for our use at a rental of £3 per day, which seemed high to us and beyond our slender means. I answered to the effect that he make a tentative offer for a few days only. We hoped to negotiate some arrangement with the regular "around the island" boat to call at Makuluva at stated intervals during our stay there, to deliver provisions and to leave or take on passengers as the members of our party shifted to go their various ways. We were all rather sad in anticipation of leaving the "Niagara" which had been our home for a very delightful passage of nearly three weeks, during which some friendships had been formed that we were loath to terminate. But such is life and we were after all glad at the prospect of getting to work and anticipated our stay in Fiji with lively pleasure.

On June 3d we had the peculiar experience of retiring on Saturday night, getting up at the usual hour the next morning, and finding that it was Monday, instead of Sunday, as it would have been in the ordinary course of events. We had passed longitude 180° during the night and thus dropped a day from our calendar.

Monday, June 5th was an eventful day for us, marking as it did the end of our long voyage and our arrival at Suva, Fiji. We were up early in the morning and hurried through breakfast as we ran into the beautiful harbor. The high, irregular crests of the mountains were dark purple, their very tips gilded by the rising sun. We passed through the channel in the coral reefs that encircle the greater part of Vitilevu, the waters became quiet in the protected harbor, and the palm groves on the foreshore were reflected in the sea. Suva came into view as we rounded a point, nestled down at the foot of the hills and embowered in trees.

Mr. Pilling, Assistant Colonial Secretary, came on board while we were at breakfast with a kindly note of welcome from Secretary Fell and instructions to see us through the Customs and to the Grand Pacific Hotel where we were to have temporary quarters. Mr. Pilling is a graduate of Oxford where he made a fine athletic record; a gentlemanly, clear-eyed fellow with a genial smile and an efficient way of looking after strangers. He summoned some bushy-haired Fijians to take our luggage ashore, talking their own language and acting as interpreter for us. The formalities at the customs house on the wharf were soon over. We sent our luggage on ahead and walked to the hotel, about a mile distant. We found the heat rather uncomfortable at first, although it was winter in that latitude, and welcomed the cool, shady verandas of the Grand Pacific set in picturesque grounds on the shore of one of the inner reaches of the harbor.

In the afternoon we called on our good friend Colonial Secretary Fell, whom we had last seen at far distant Barbados four years before, and talked over our plans. In his office was a Fijian with a most imposing head of hair and extremely dignified bearing. We afterward became well acquainted with him and succeeded in securing a photograph, largely for the sake of his hair, which illustrates the typical Fijian head-dress at its best. Later Mr. Fell took us on a delightful auto ride along a road following the shore and then inland where it penetrated the bush among the foothills thus giving us a taste of the jungle with its wealth of luxurious tropical vegetation almost unmodified by man. The little island of Makuluva was pointed out to us in the distance and, of course, I was interested in what was to be my home during about half our stay in Fiji. There were several Indian villages along the road and one that was typically Fijian. Mr. Fell told us that there were few mosquitos and no venomous snakes on Vitilevu, which is notably free from harmful insects or other pestiferous things which make one uncomfortable. The Indians (or "Hindus," as we would call them) are of lighter build than the Fijians and not so guileless, as was indicated by their faces, which often had a crafty expression. Many of them, having served their time under the indenture system, were about to start back for India the next day.

Government House had burned down recently, and Mr. Fell was living on a Government yacht, having turned over his residence to the Governor.

The Grand Pacific Hotel is one of the most imposing structures that we saw in Fiji. The servants are all Indians with picturesque costumes of white and red fezes and sashes of blue and yellow. We Americans were insatiably thirsty and found it hard to get enough drinking water until finally the waiter, with an air of desperation, brought us each a glass "schooner" about eight inches high and set it down with a thump, amid many expressions of fervent appreciation on the part of the Americans.

CHAPTER III

LIFE ON MAKULUVA

On Tuesday, June 6th, Mr. Pilling took us on a Government launch for reconnaissance of Makuluva and the neighboring reefs to judge its suitability as a base for our reef work. The island is nine or ten miles to the east of Suva on the south coast of Vitilevu and is reached by an inside passage between the mainland and the reefs that extend in broken series clear around to the north shore. It is sharply outlined by a long line of foaming breakers that pound incessantly over the seaward faces of the reefs and roar across their entire width at high tide. The landing is very bad as the bottom is strewn with coral rocks, and the swell is quite heavy most of the time. There is no safe anchorage and scores of anchors have been lost there by small sail-boats, launches and yachts. Very often the coral rocks are cemented so solidly to the bottom that they cannot be broken loose. The difficulty in landing is the greatest drawback to the island.

A small rowboat from the launch set us ashore. We found the tide low, giving us a good opportunity to inspect the flats and reefs with which we were soon to become so familiar. We went out from the south end of the island wading through shallow water to the flats which extended half a mile or so to the outer edge of the reef and several miles in a general east and west direction. The landward side of the flats was not particularly attractive from the naturalist's standpoint, although we saw many brilliantly blue starfish of large size and any number of serpent stars. The farther we went the better the prospect, however, and we were soon passing over acres of compound anemones, flabby alcyonarians and small patches of coral. Masses of worn coral rock, riddled by boring mollusks and sea-urchins, as well as by weathering, provided inviting retreats for mollusks and crustaceans; and, as we later discovered, for brilliantly colored reef fishes which found refuge in the crannies at low tide. Nearer the outer edge of the flats the fauna was more and more abundant and the tide pools became wonderful natural aquaria that could hardly be surpassed in beauty and wealth both of animal and vegetable life. We felt sure even from this hasty examination that there was material and work here in abundance.

Our attention was next focused on the island of Makuluva itself and its facilities for quarters and laboratories for our party. The island is about ten acres in extent roughly quadrilateral in form and lies about a third of a mile from the larger island of Nukulau which is used as a quarantine station for blacks (meaning Indians and Fijians) and is presided over by the care-taker, a man named Sadler, with whom we became acquainted later. Makuluva itself is the Government quarantine station for whites, but of late years there has seldom been occasion to use it for that purpose. We found the quarters and buildings in good condition. The building that we used for living rooms and laboratories was a long, neatly painted wooden structure with a central hall running through it from north to south and a range of sleeping rooms on either side. Each of these was large enough to accommodate a man very comfortably and all of them opened on to the central hall on one side and a roomy, breezy veranda on the other. Each had a cot, a washstand with basin and pitcher, a chair or two and a kerosene lamp. Mattresses, pillows and bed linen were also provided. The wide porches on the east and west sides gave admirable laboratory space where we could work in comfort all day, using the west side in the forenoon and the east veranda in the afternoon, thus avoiding the sun at all times.

Beyond the south end of this building and connected with it by a covered walk was the dining hall with large tables and several other smaller ones that we used in our work. There was ordinary tableware in abundance and a swinging lamp for the evening. The windows had heavy board shutters as protection in case of a hurricane. South of the dining hall was another building, a duplicate of the one first described and on one side a cook house with a range and usual kitchen furniture. On a convenient platform next the dining room was a pump which drew water, or rather was expected to, from a large cistern beneath. This solved the extremely important question of water supply, although we had to draw the water in buckets as the pump refused to function properly. Other buildings, smaller and roofed with corrugated iron, we did not use, except one for our Indian cook and one for the two Fiji helpers.

Makuluva is an exceedingly attractive little island from a scenic standpoint with many graceful coconut palms, no underbrush and with open spaces covered by a green grass that we afterward found to be excellent material, when dried, to use as packing for the fragile branched corals.

We felt very well pleased with the prospect of abundant marine material and a comfortable home while engaged in reef work. On the way back we visited the neighboring island of Nukulau and met the keeper, Mr. Sadler, who agreed to call on us once in a while to see how we were getting along and also to bring such supplies as he could furnish. He is an Australian who has spent his life roaming about the South Pacific and can tell stories of his varied adventures that would make Frederick O'Brien sick with envy.

Our most difficult problems were transportation to and from the island and the matter of delivery of supplies at regular intervals from the nearest market, Suva. We met Mr. Andy Smoothy that evening, a man who owned several launches and had the confidence of Secretary Fell. We really had no continuous use for a launch as there was no way to keep it safely near Makuluva, there being practically no shelter in stormy weather or even a safe anchorage. Moreover, we had no intention of trying to dredge as we lacked dredging equipment and none was to be had at Suva. Further, it was evident that the water was too rough outside the reefs and too shallow inside. Mr. Smoothy understood the situation and after thorough discussion the following plan was agreed to by both parties: On June 7th his large launch was to take the party to Makuluva with the entire equipment for laboratory and reef work, personal luggage, and supplies for about a week; he promised to help us land on Makuluva and then take the launch back to Suva the same day. On June 12th and 17th the small launch was to take any of us who desired to go to Makuluva, land us, together with provisions for about a week, and return with any members who desired to leave the island. On June 22d the large launch was to take the entire party, equipment and collections back to Suva and land them there. In this way we would have to pay not more than four days' launch hire and would be relieved of the responsibility of keeping an expensive boat in the dangerous water around Makuluva.

Mrs. Stoner undertook the purchase of necessary supplies at Suva and their delivery to the island on the days agreed upon. Secretary Fell very generously provided a whale-boat belonging to the Colonial Government for our use. Mr. Pilling found an

Indian cook named Kalidin who agreed to serve at 25 s. per week, and board. A Fijian boatman, named Alfred, was secured for the reef work and his fourteen year old boy went along as interpreter between the Americans and the Fiji man on the one hand, and the Indian cook on the other. He was also to act as cook's assistant, chamber maid and general utility boy.

The next day, June 7th, was a busy one for all hands. Through a misunderstanding the motor lorry which was to take our baggage from the hotel to the wharf did not appear. Mrs. Stoner and Glock attended to the purchase of provisions for the first week, Stoner and Wylie saw to the transfer of our equipment from the customs house on the wharf to Smoothy's launch at another dock, while I settled the bills at the hotel and waited near the telephone to correlate matters when there seemed to be a hitch. When the lorry failed to appear, I procured a taxi and took our effects to the dock.

It was about one o'clock in the afternoon when we arrived. Mrs. Stoner stayed behind, but Dr. Stoner and Professor Wylie were to return in the evening after assisting with the landing and housing of our equipment at Makuluva. We called at Nukulau on the way and saw Mr. Sadler who gave us the keys to the buildings we were to occupy, the bed linen, and silverware for the dining-room table. Landing at Makuluva was difficult as the surf was high and Mr. Smoothy insisted on transferring the party and all of the luggage and equipment in one boatload. As a result we shipped a sea or two; the whale boat had a foot or more of water in the bottom and the boxes containing the microscopes and micro-photographic camera were considerably damaged.

It was hard work for all hands carrying the heavy boxes ashore through the water and over the slippery rocks. Wylie and Stoner, who were going back to Suva, wanted to get some of their equipment from the boxes to take back with them. It was getting late in the day and Smoothy was anxious to return with his launch before dark. The lock on a box containing the tools for opening the other cases would not work and had to be forced open. All this contributed to a scene of disorder and confusion on the beach. Most of us had had no lunch and were in rather bad humor, but finally the two men who were to return to Suva located most of the things they needed and left Thomas, Glock and me with the servants, to face the approaching night and stow away the numerous items of equipment scattered along the beach.

The cook brought most of the provisions to the cook-house and soon had a fire going; our Fiji man and boy helped carry the cases to the quarters, while Thomas, Glock and I got as many things under shelter as we could, placing them in one of the little houses near the shore where they would be safe for the night.

Kalidin, the cook, did nobly and served a supper of tomato soup, ham, potatoes, rice, bread and butter and coffee that certainly tasted good after our hard work and fast since early breakfast. We retired early for we wanted to get a prompt start in the morning for the first day's real reef work.

We arose at six the next day, just as the sun was about to rise in a blaze of glory, and took a dip in the surf at a good beach of smooth sand on the east shore. The surf was quite heavy, the bottom stony a little way out and, we were somewhat afraid of an undertow which was evident but which proved not to be dangerous. One is likely to be rolled and scoured over the stones as the surf breaks high on the beach and surges back amid the grinding of pebbles and rolling of loose stones. Swimming is difficult under such circumstances so we satisfied ourselves with a few dives through the oncoming breakers and returned to our veranda for a fresh-water shower and rub-down.

We dressed in reef costumes of shirt, trousers and heavy shoes to withstand the sharp rocks of the flats, as well as broken shells and sea urchins' spines. Our Fijians were clothed in breech-clouts only. Each of the party took a fiber bucket and a number of stoppered bottles of various sizes, and one of us always carried a "crow foot" bar for overturning rocks and breaking loose the various things found cemented to the reef. The Fijians took spears for securing the larger fish, a sport which they keenly enjoyed and at which they, especially the man Alfred, were remarkably efficient.

Although the fauna of the flats and reefs of Makuluva will receive detailed description in a subsequent chapter, its general facies can best be shown by extracts from my notes on my first day's work, June 8th.

The most conspicuous animal on the inshore flats was a big blue starfish somewhat allied to *Linckia,* often with six rays. Of echini there were the common *Echinometra lucunter,* a fragment of a petalostichan test; very fine urchins with barred purplish brown and white spines of two kinds, a shorter ordinary set, and another very slender and finely barbed set and knobbed pedicellariæ. These spines remind one of *Aspidodiadema*. Of serpent stars the most common was a black *Ophiocoma.* There was a smaller species barred greenish and white, one with brilliant scarlet on the upper side of rays, and several others. There were holothurians mottled chocolate and white in color, and black forms allied to *Stichopus,* with tubercles of the same color; also, a smoother black one said by our Fijians to be edible.

Of the Crustacea there was a small blue crab on the big blue starfish; mantis shrimps mottled greenish and whitish above and with four marginal purple spots, appendages green with white spots on margins, and chelæ tipped with purple. Another, a macruran, was a greenish form with red walking legs and very large chelæ. Of brachyurans there was a quadrate form, blood-red and green with whitish lines, allied to the "Sally light-foot" of the West Indies. The number of crustaceans in any good locality was prodigious. Alfred broke open a mass of coral rock and secured a remarkable slender legged macruran, white, with blood-red annular markings on the body and appendages, the latter bearing many spines and conspicuous markings of bright blue on the red annulations.

There was a profusion of various kinds of mollusks. Perhaps the most interesting (to us) was the well known *Tridacna* which attains the greatest weight of any modern bivalve. It will be described later. There were several *Turbo, Leucozonia, Cerithium* and a heavy gastropod with a remarkably thick operculum, hemispherical in shape; three species of *Conus,* a *Crepidula* adhering to a *Turbo, Spondylus,* several fine species of *Cypræa* and a *Natica.* Interesting nudibranchs were common; one, white mottled with brownish and another bearing eggs on its back. A small *Octopus* emitted much ink when disturbed. There were several worms, one related to *Nereis,* a very slender brown and yellow annelid and some tube-dwelling forms.

Perhaps the most interesting assemblage we saw was a profusion of Cœlenterata, among which were a brilliant blue hydrocoralline, corals belonging to the genera *Agaricea Meandrina, Pocillopora, Siderastræa,* very brilliantly colored *Acropora* and other genera not familiar to me. There were literally acres of compound anemones, very large simple ones with numerous brilliant green tentacles, orange red bodies and profusely lobulated oral discs. A beautiful alcyonarian grew in large lobular patches with few definite branches. It was grayish in color with very prominent non-retractile polyps—a very fine form for class use. We also found small colonies of "organ-pipe coral," and a tabulate alcyonarian.

A number of sponges were collected but I never attempt identifications in this very perplexing group. Many brilliant reef fishes were seen in the tide-pools near the outer edge of the reef but no attempt to collect these was made that day.

Reef collecting is downright hard work, especially under a tropical sun, trudging over the uneven surface of the flats and stumbling through the shallow pools. Each of us soon had his bucket full of specimens, the smaller ones in bottles and the larger ones loose in the bucket. After a half mile walk back to the island hurrying to avoid the incoming tide, waist deep in a tide-current part of the time, the bucket becoming heavier every minute, we were almost exhausted when we finally reached the veranda in which we were to install our laboratory.

A change of clothing and a good dinner prepared by Kalidin made us quite fit for the afternoon's work of caring for and making a preliminary study of our morning's catch. The Fijians brought fresh sea-water to fill all of the buckets and the square galvanized iron pans we had found so useful in previous expeditions. Bottles of various sizes with their stoppers were set out on the tables, the labels were put out ready to use and the alcohol and formalin placed where they were at hand for the final preservation of the "wet" specimens.

Nothing but a rough approximation in the classification of specimens was attempted, the mass of material being so great that it was a task to put it all in safety before night. Color notes and brief descriptions of some of the most interesting forms were made, labels written, and the specimens put in preservative as rapidly as possible after which the veranda was cleaned up for the following day's work. By the time all this was accomplished we were quite ready to quit work and go to supper.

The 16-foot whale boat turned over to us by the Colonial Government proved an elephant on our hands. As a matter of fact we had no use for a rowboat in the shallow water inside the flats and the surf was too high outside. The boat was too large for us to manage with the force at our disposal and had no anchor large enough to trust. Moreover, the whale-boat was too heavy for us to draw up on the beach. Alfred found a piece of iron with which he anchored it, but it washed ashore, filled before morning and the heavy waves pounded it badly. Finally, we got Mr. Sadler to take it to Nukulau where there is a protected wharf, and we did not attempt to use it at all.

Alfred took great delight in spearing fish. One day he brought in a big parrot-fish, red and blue, weighing six or eight pounds. For some reason he wore a sort of wreath made of a vine or weed called "mile-a-minute," giving him the appearance of a victor in the Olympian games. The fish was served for dinner but was not particularly palatable. Another time I was with him on the reef when he speared a four-foot shark at a distance of about 30 feet and there was a lively fight before he finally dispatched it with the crow-foot bar. He declared that this particular shark with black-tipped fins and tail was his "devil" because one of them had bitten a generous piece out of his grandfather. He maintained that it was good to eat but tabu to him. Kalidin, the cook, said that it was very bad fish to eat, but it seemed to be a habit with him to deny any statement made by the Fijians. Always ready for gastronomic experiments, I ordered it cooked for dinner; Wylie and I pronounced it excellent, equal to any ordinary table fish and better than any other shark I had tasted.

Another experiment in the eating line resulted in great hilarity. A big black holothurian, abundant on the flats, was brought ashore by Alfred who said it was good to eat. We told the cook to serve it and it looked rather attractive; the black outer skin contrasted with the ivory white body wall, which somewhat resembled the meat of a fresh coconut. We found it rather tough but easily cut with an ordinary table knife. Then the fun began. The tines of the fork punctured the meat easily enough but it could not be lifted to the mouth on account of its remarkable elasticity. As soon as the pressure of spearing was released, it fairly snapped off the fork as if actuated by a spring! The thing was so unexpected and extraordinary, and the expression on the face of the diner so ludicrous that the others fairly roared with laughter. Again and again we tried to use the fork after the manner of polite society but found that it simply could not be done. Afterward we took huge delight in witnessing the attempts of a belated member of our party to dine on boiled holothurian. As a matter of fact the thing was tough, almost tasteless and no addition to our cuisine.

Many of the coconut plams on Makuluva have their leaves blighted by the larvæ of a small blue moth. This insect seems to be confined to Vitilevu and some of the smaller islets around it, but has not yet made its appearance on the other large islands of the Fiji group. We were told that the Colonial Government, in order to ascertain their natural parasitic enemies, had a standing offer of one hundred pounds to anyone finding them living elsewhere.

Just off the southwest shore of our island was a magnificent patch of thriving corals of the finely branching kinds, which made a beautiful sight when the water was calm. Each of the hundreds of fine branchlets was tipped by a group of calyces consisting of a madrepore and a few adjacent polyps, which were colored a bright bluish pink, sometimes lavender, in strong contrast to the soft gray brown of the rest of the branches. Wylie succeeded in getting some very satisfactory photographs of them when completely submerged. We found a big head of *Orbicella,* perhaps two and one-half feet across with a dense mass of expanded polyps rising nearly three inches above the surface,—the finest display of living coral polyps I had ever seen. Here also was the largest anemone any of us had encountered. It must have been eighteen inches across the disc, but it was impossible to secure it as it shrank into a tiny crevice of flinty-hard rock at a touch.

One of the most devilish contrivances I know in the way of a mantrap is the *Tridacna* or ''giant clam'' which is rather common on the Makuluva flats. These sometimes attain enormous proportions which make them the largest and heaviest of all modern bivalves. I understand that one is used as a baptismal font at Notre Dame in Paris. Those at Makuluva were comparatively small, but extraordinarily hard and solid. They lie on the surface of the rock dorsal side down, and are firmly anchored by a byssus which is almost as tough as a good three-quarter inch hemp rope. It is impossible to tear one off with the hands, even if it is no more than eight inches long; indeed, a crow-bar must be used. The exceedingly hard valves have regularly scalloped margins which fit each other with great nicety. When alive, the clam habitually holds these valves open from two to eight or ten inches, according to the size of the individual mollusk. If the collector, by an incautious step, puts his foot between these valves, or in feeling with his hands under a rock gets his fingers in the trap, the valves snap shut with the unrelenting grip of steel, and the unfortunate victim is absolutely helpless, if alone on the reef. No amount of frantic struggling will release him, neither will the utmost exercise of his strength tear the creature from its anchorage. We heard most tragic stories of victims being held thus until the rising tide put an end to their lives.

On one occasion, while working on the tide flats, I put my hand under a rock and received a slight cut on the little finger, as clean a cut as if made by a scalpel. In a few seconds the pain became so severe, even excruciating, that I feared losing consciousness and toppling over in the shallow water. I contemplated the ignominy of drowning in less than a foot of water. The finger was red, bled slightly and was slightly swollen. The severe pain gradually subsided and was completely gone within an hour. My Fiji man said that the wound was inflicted by a little fish no larger than one's finger and that it had sharp horn-like spines about its head with which the cut was made. We afterwards secured some of these fish, or at least they were so identified by Alfred.

The stings of sea urchins' spines, cuts from sharp shells and jagged rocks and the spicules of sponges are hard on one's hands. Certain polychætous annelids have tufts of fine setæ that are extremely poisonous, stick into one's fingers by the hundreds, and are as hard to remove as the minute spines of the prickly pear. Our hands were often quite sore from one or several of these causes. Of course rubber gloves can be worn, but these make the handling of small specimens difficult and most of us preferred using our bare hands and taking the consequences, painful as they were.

Several species of morays or "eels" were abundant on these flats; the larger ones are quite aggressive and able to inflict serious wounds with their numerous, needle-like teeth. They are greatly disliked by fishermen and dispatched whenever possible.

On Sunday we rested, shaved and cleaned up generally. I was quite astonished while shaving with my Gillette to have Esile, the fourteen year old Fiji boy, ask me for a spare blade for his father to use. I told him that it was of no use without the rest of the razor, whereupon Alfred produced a blade-holder which he said came originally from Australia. The blade fitted and Alfred proceeded to shave, seated Turk fashion on the ground.

We strolled around our little domain which was really a most attractive spot, nearly surrounded by reefs over which the breakers dashed with thunderous noise resembling distant cannon fire.

There was a paw paw tree near our quarters, but the fruit was not ripe. Minah birds were common and Stoner procured several, incidentally getting from them several interesting parasites, some of which appeared to be new. A few herons visited the shore occasionally and we were told that the large fruit-bats or "flying foxes" roost in some of the trees at night; however, we saw none of them. The boy brought us some of the eggs of a small lizard which he found under the bark of a tree. They were round and as large as small marbles, indeed they seemed out of proportion to the size of the animal itself.

Coconut palms are the most abundant trees here, but there are a number of others, usually near the east shore, which have grotesquely twisted branches and dark leaves. They are called "butterfly trees." Another tree has large glossy leaves and nuts encased in a very light spongy tissue which floats it in water. The whole affair looks much like a round sponge. We were told that the enclosed nuts, or seeds, furnish a poison used by the natives to kill fishes.

Speaking of nuts reminds me of the facility with which the Fijians climb the coconut palms. When we wanted some of the milk to drink the boy climbed the long slender trunks like a monkey and threw down as many nuts as we wanted. The novice has much trouble in removing the dense fibrous outer husks; but Alfred used a pointed stick, set the blunt end on the ground where it was braced against a log and forcibly drove the nut against the sharp point; thus it was hulled in a fraction of a minute.

The Fiji lad, Esile, was a very bright little fellow much interested in all our doings. We found him a keen collector and he secured many specimens that otherwise might have escaped us. The facility with which he learned new words, even technical scientific terms, was highly amusing. It sounded really weird to hear this naked boy, removed from savagery by no more than two generations, exclaim—"Look, here is a nudibranch," or to announce the discovery of a new kind of "holothurian." He was quite useful in interpreting Fijian into English or vice versa, or either of these into Indian for the benefit of the cook.

On Sunday the talk turned to religion and we learned that the old Fijians practiced a "devil worship," but that Alfred was a good Wesleyan Methodist. Many of the old superstitions were retained, however, and he declared that he would never dive near one of the reefs to the southeast of Makuluva because the spirits of all the departed Fiji chiefs dwelt there and he was afraid they would catch him. He thought that Fiji ought to belong to the United States as the first visitors to reach these islands were Americans.

The boy caught a chicken which seemed to be running wild on the island and thus secured a *piece de resistance* for our Sunday dinner. That was fortunate, because about noon Secretary Fell and two other officials, Mr. Holmes and Mr. Caldwell, paid us a visit in a launch which they used in their fishing excursions, and brought along a lot of good things to supplement our lunch. We, therefore had quite a feast, although Mr. Sadler, who came from Nukulau, claimed that the chicken belonged to him. We took our visitors for a stroll on the tide flats and showed them some of the interesting things we had collected. Among the latter was a curious puff-fish mottled with light and dark greens and white polka dots on its back. It had a comical way of slowly winking its rather prominent eyes, sometimes closing them altogether as if asleep. Then there was a very large and brilliant nudibranch in vivid hues of scarlet, crimson and white, which swam with graceful undulating motions in a pan of sea water.

That night I developed a roll of film which I had used that day and found it absolutely blank! It had been packed at the factory with a strip of black paper in front or on the emulsion side of the film. This was disheartening as there was no knowing how many rolls had the strips reversed in the same way. We had considerable trouble in developing films on Makuluva on account of the warmth of the water and the absence of ice. As a matter of fact we found it safer not to develop on the island but to take our exposed films to a photographer in Suva, who had a fairly good developing room and equipment.

On Monday, June 12th, the small launch came from Suva with provisions forwarded by Mrs. Stoner. Wylie also came for his sojourn on the island, while Thomas and Glock returned in the launch to Suva. The tides were daily becoming less favorable and the collecting fell off somewhat, but there was still plenty to occupy us. Each day we found the area of flats laid bare at low tide perceptibly decreased, and we could hardly get to the outer edge of the reef at all on account of the big rollers that swept in at irregular and unexpected intervals.

The moonlight nights were glorious during the first few days of our stay, and we enjoyed the evenings when supper was over and the day's work done. I had brought along my flute and the Fijians made an appreciative audience, expressing their pleasure by a curious clicking sound. We shall never forget those wonderful moonlight nights with the rustling palm leaves showing their glistening silvery edges projected sharply against the sky, while the sheen of the moonlight path on the ocean danced and quivered with the ripples. The thunder of the surf, sounding like big guns at high tide, was reduced to little more than a deep murmur when the tide was low. When the moonlight nights passed we enjoyed the solemn splendor of the southern constellations in their nightly procession. The Southern Cross, high toward the zenith, seemed more brilliant than in the West Indies where we had considered it a much over-advertised attraction. Near it was the great black space or "hole in the sky" almost devoid of stars.

More splendid than the moonlight or the glory of the star-lit heavens was the sunrise seen every morning as we took our dip before dressing. The scarlet reddening of the east as "the rosy-fingered daughter of the morn" appeared was soon illuminated by flecks and streamers of golden fire as the sun seemed almost to leap above the horizon. After that it behaved strangely, according to our Northern hemisphere ideas, for it rolled around to the north instead of the south towards its setting over the distant mountains of Vitilevu.

During the night there was usually a strong and constant breeze through our sleeping rooms, and it was never uncomfortably warm. Sometimes a strong wind arose so that it was necessary to shut the doors and once or twice we had to adjust the heavy shutters to the windows. The island was very low with no portion of it more than twelve or fifteen feet above the water. On some occasions, we were told, it had been invaded by the sea during hurricanes at high tide, but evidently it had not been actually covered by water since the building of the quarantine station. We had provided ourselves with mosquito nets for our cots, but had no occasion to use them here, although there were a few stray mosquitoes on one or two unusually quiet nights. The rainfall is much less on Makuluva than on the mainland opposite, only a couple of miles away, and it rarely interfered with our work, although heavy storms could be seen over Vitilevu.

One day when Dr. and Mrs. Stoner and I were in the middle of the messy work of sorting out a morning's catch, and were all

Our servants at Makuluva—Fijian reef man and Indian cook (See page 39)
Our quarters at Makuluva (See page 37)
(Photos by Glock)

PLATE VI

Making a basket of a palm leaf (See page 50) Climbing for coconuts
(Photos by Glock)
Alfred husking a coconut (See page 46) (Photo by Thomas)

in our disreputable looking work clothes, Esile, the Fiji boy, announced that the Governor's launch was casting anchor near the landing. We had no chance at all to "slick up" and I went down to the shore to welcome His Excellency, Governor Rodwell, Commissioner for the Mid Pacific possessions of Great Britain, Lady Rodwell and her children, Mrs. Pilling and some others, all in spick and span outing clothes. I must have made a sorry sight and found it difficult to do the honors as a representative of the United States and the University of Iowa. However, I stepped into the water and helped the ladies ashore while His Excellency came on the back of a Fiji boy. Another Fijian acting as aide to the Governor wore the native costume of a sulu plus a white shirt, and the characteristic bushy hair approved by his race. He was Ratu Sukuna, a native chief of high rank and an Oxford graduate. He spoke the English of a cultivated gentleman and had the manner of a highly educated and polished man. We were told he had been refused admission to the British army during the great war and had then enlisted in the Foreign Legion in France. He was then the official head of the Fijian Navy, we understood. Our man Alfred told me that every Fiji man, woman and child had contributed a shilling (no mean sum for them) to send Ratu Sukuna to Oxford, and that they were all immensely proud of him and wanted him to go back for graduate work! There is no doubt whatever about the loyalty of the Fijians to their hereditary chiefs, and this man belonged to the royal line of the old Fiji kings. Two or three generations ago they were all cannibals.

I had a chat with Governor Rodwell on the veranda while the ladies and children went for a "bathe," as they expressed it. Our little beach is about the only good sandy shore anywhere near Suva and is a very popular resort for European families who often come to spend a week-end or short vacation on this delightful little island. I am sure that we hardly realized what a hardship it was to these people to have Makuluva handed over to a party of strangers from far away Iowa, thus depriving the colonials of a favorite picnic ground. The Governor seemed interested in what we had to say of our University and in the book of photographs we had taken along. I doubt if His Excellency had so much as heard of the institution we represented before our correspondence with Secretary Fell began. He did appreciate, however, the fact that our visit was likely to result in good publicity for Fiji, and he expressed himself as pleased at our advent.

Our commissary department functioned in a satisfactory manner, Mrs. Stoner sending out supplies from Suva every five days. Our Fijians speared edible fish occasionally, the best of which were some flounders, and Mr. Sadler brought a few fish, a chicken and some lemons from Nukulau. He has had many weird adventures in the South seas, is very fluent in their narration and evidently enjoyed an opportunity to talk with members of our party. His life on Nukulau, where he is keeper of the quarantine station for natives and Indians, is doubtless a lonely one, although relieved, so we were told, by a succession of no less than eight Polynesian women who took charge of his domestic affairs for periods of uncertain length. At the time of our stay he was temporarily a "widow," as he expressed it.

Mr. Sadler had no great love for the Fijian and still less for the Indian; he felt much aggrieved at the latter for his refusal to work while in quarantine. He said that when an Indian made up his mind to die nothing could prevent his doing so. On one occasion a Hindu felt aggrieved because the Colonial Government refused to allow him to keep two wives, insisting that he dispose of one. He calmly wrapped his blanket around his head, sat down in about three feet of water and succeeded in drowning himself. If this narrative is true, we have here an astonishing case of almost superhuman self-control and an evidence of strength of will that would be hard to surpass.

Dr. and Mrs. Stoner were the last ones to work with me on Makuluva, and I was glad of it, for the last days were occupied largely in packing our collections and equipment in which Stoner is an experienced and capable man. The reef work was poor during their stay on account of unfavorable tides, but he found plenty to do with the birds and insects of our little island.

We packed the corals first; they were easy enough to collect in any desired quantity almost at our very door. We had brought ashore a number of beautiful museum specimens and placed them to dry on a wooden platform near the beach. Many of them were extremely delicate branching forms, brittle as glass, and we almost despaired of packing them so that they would withstand transportation on the long voyage from Fiji to Iowa. Alfred made baskets of palm leaves in which they were carried to the laboratory in about ten minutes. Several of the larger and finer specimens were packed separately in strong boxes, and we took every precaution we could invent. We used fine toilet paper in little wads packing them firmly, but not too forcibly, in and around the very bases of the branches and building gradually outward towards the tips. Then we collected a quantity of coarse dried grass which almost covered the island, pressed it in between the tips and built out beyond them so that we had a light but rather firmly compacted ball somewhat larger than the extreme measurements of the corallum. Next they were placed carefully, each in a separate box, and dried grass packed around so that no portion of the specimen touched the container. One by one these boxes were packed and nailed up, numbered and carefully labeled with printed pasters brought for the purpose. As a matter of fact, our packing was fairly successful as only one big specimen was badly broken in transit to Iowa City.

The smaller corals, dried mollusks and echinoderms were easily packed in whatever boxes were at hand, so that the dried material was soon disposed of.

We had collected quantities of specimens of the commoner kinds for use in the zoological and botanical laboratories, and they were carefully packed by Wylie before he left. We also had tanks in wooden cases for stock laboratory material in which we placed quantities of the big blue starfish and other wet specimens, wrapping some of them in the dried grass for protection, and then pouring in the alcohol or formalin as the case seemed to require. The smaller wet material, and this included most of the more valuable specimens collected, was packed in the special collecting chests devised by my friend and former pupil, Dr. Paul Bartsch of the United States National Museum. Each chest contained square bottles with cork lined metal stoppers which screwed on. A small amount of melted paraffin was poured into each stopper which also had a layer of cork supposed to fit tight against the top of the bottle when screwed on. The paraffin and cork together usually sealed the bottles in a satisfactory manner. Still smaller specimens were placed in small wide-mouthed bottles and vials, each cork tied on and then dipped in melted paraffin.

All this took a good deal of time. Stoner was not feeling well on account of a cold contracted on collecting trips but he stuck to his task to the end. Then the microscopes, photographic material, books, charts and miscellaneous equipment had to be carefully repacked and the contents of each box listed so that the various articles could easily be found during the remainder of our stay in Fiji, and later, in New Zealand.

All of these boxes, tanks, etc. made quite an imposing array of impedimenta when the packing and marking was finished. We transferred a good deal of it to an empty but water-tight house near the landing so that time might be saved when the boat came to take us away.

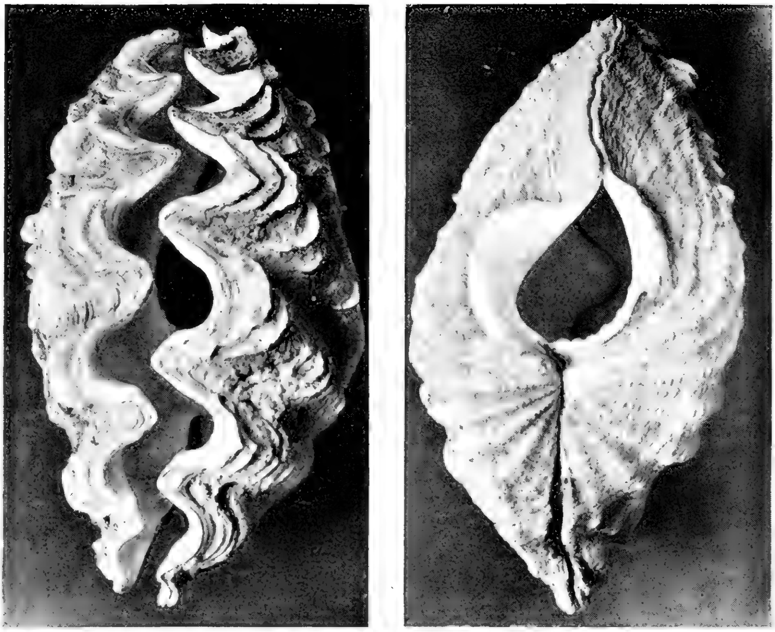
Thursday, June 22d, found our packing complete and all hands ready to leave Makuluva, although it was about as near a naturalist's paradise as I ever expect to see. Nevertheless, in spite of its great interest, reef work is no light job and, if pursued energetically, it thoroughly tires one before the end of each day. Work in the hot sun is more than the average man can withstand for a period of two or three weeks without coming uncomfortably near the limit of his strength. We had been well fed, however, thanks to Mrs. Stoner and the cook, and that helped a lot. The powdered milk called "klim" that we brought from home was a great success, indeed, better than the milk that we had at the Grand Pacific Hotel at Suva, and there was enough of it to use freely. We managed not to depart materially from accustomed food habits and had little opportunity to experiment with strange tropical fruits. Most important of all, we avoided the strange and weird concoctions in the way of drinks that so often tempt the traveler to his injury.

The Government launch, Andi Viti, which translated means "Fiji Queen," sent by Secretary Fell with his usual forethought, made its appearance about 11:00 A.M., towing a capacious whaleboat in addition to the one we had left with Mr. Sadler in Nukulau; Sadler himself came to assist in embarkation. He advised us to load on the west instead of the north side of the island, and this proved an excellent idea as there was a good sandy beach and almost no surf at that time. It was a big task to carry all our things out to the whale boat, but we had several Fijians who came in the "Andi Viti" in addition to our party and Mr. Sadler. Before leaving we gave a crab net and collecting bucket to Alfred in addition to his wages. I also bestowed on him an old shirt, a pair of old trousers much frayed at the bottom and a pair of old shoes which seemed beyond mending. He seemed overjoyed and declared, in effect, that he was my servant forever. We had worked together and I imagine he had achieved some sort of affection for

PLATE VII

My Fiji reef man in reef costume (See page 43)
Surf roaring over Makuluva flats (See page 40) (Photo by Thomas)
Makuluva flats at low tide (See page 42)

PLATE VIII



Ventral and dorsal views of giant clam (See page 44)
Abdomen of "robber crab" showing unpaired appendages (See page 67)

us, as had his bright boy Esile. The cook was much less demonstrative and I imagine he was somewhat jealous of the attention we paid the Fijians. Last of all we presented Mr. Sadler with a bucket, crab net, small seine and, what pleased him most, a small tight cask which had contained formalin. He said that it was just what he needed for a water cask to carry in his little sail-boat when he put out on his fishing trips.

In about an hour we were all on board the Andi Viti and making our way cautiously through the channels between the reefs, bound for Suva. We could hardly repress a feeling of regret at leaving our delightful island home, for it had certainly been good to us. We made quite a procession with the handsome launch conveying our party and the personal luggage, with the two big whale boats and Mr. Sadler's small boat trailing behind. We called at Nukulau to leave Mr. Sadler to his loneliness. We reached the dock about noon and found no one there but a mob of chattering Fijians who understood not a word of English while we were equally ignorant of their language. Leaving the Stoners with our goods, I went to the customs house wharf where I found an obliging official who telephoned for a lorry to take our collections and equipment to the wharf where they would be in charge of responsible officials. Two of our tanks leaked badly and caused considerable trouble until Stoner got hold of a tinsmith who soldered them successfully.

I went to the Fiji Club where, through the kind offices of Mr. Pilling, a room had been assigned me. This club is owned and run mainly by colonial officials and is very comfortable; it is built on a hill overlooking Suva Bay on one side and the city on the other. In the evening I was introduced to a number of the members who usually gather there before dinner for a social hour. They are a fine lot of men to whom we were greatly indebted for comfortable quarters and many courtesies during our stay in Suva.

I found that the next day was a legal holiday (the Prince's Birthday) and that the banks would be closed. This was disquieting as I had promised to pay off my Fijians and the cook at the bank on that day, and I was particularly anxious to keep my word with those men who had served us so satisfactorily. I had decided to take my meals at the MacDonald Hotel, and at breakfast the next morning when I told the manager about my difficulty he at once offered to cash a check for me for the necessary amount (£8). Being an absolute stranger to him I was surprised at the somewhat unexpected courtesy. I learned afterward, however, that this was by no means an exceptional incident. As a matter of fact there is a very slim chance for anyone to defraud by passing bad checks in Fiji, as it is practically impossible to leave the island without making one's intention known to the officials in advance. Neither would it be practicable to escape into the interior, as a white stranger would be a marked man anywhere and reported at once to the police.

So I had the pleasure of paying off our servants in full. I found them very keen about getting the last possible shilling due them. The Fijians seemed well satisfied but Kalidin, the cook, protested rather vigorously about something or other. His remarks were not translated to me and he finally subsided and accepted the pay originally agreed upon.

Wylie, Thomas and Glock were off on a trip to the interior with Secretary Fell, who had very thoughtfully invited them to accompany him on a sort of inspection tour to the very heart of Viti-levu where they could get a taste of tropical nature practically undisturbed by man and see the aboriginal Fijians in their primitive condition. Professors Wylie and Thomas will relate their experiences on that wonderful adventure in another chapter of this work.

CHAPTER IV

THE FAUNA OF MAKULUVA REEFS

Having previously worked mainly in the tropical Atlantic it is but natural for us to make certain general comparisons between the reef fauna of the West Indies and that of the western South Pacific as represented by the reefs of Fiji.

One of the first things that surprised us was the generic identity of many typical forms in the regions compared. Most of the corals were of genera already familiar to us such as *Porites, Acropora, Orbicella, Agaricea, Siderastraea,* etc., all found abundantly in the West Indies, although the species seemed different, as would be expected. Among the echinoderms were a handsome blue *Linckia,* the commonest starfish on the flats, the familiar genera *Ophiocoma* and *Ophiothrix,* the widely distributed sea urchin *Echinometra lucunter* and a *Diadema* or a similar form. The mollusks were mainly of familiar West Indian genera such as *Cerithium, Turbo, Cypræa, Natica, Conus, Murex* and *Triton.* The crustacea, too, were chiefly of familiar genera. Taking it all in all there was much less difference between the fauna of the two areas than one would suppose, although Agassiz has called attention to the same fact in his book on the coral reefs of Fiji, and elsewhere.

Of course, we found many genera in all groups that are absent or rare in the West Indies, such as *Pocillopora, Fovites, Leptoria* and others among the corals, while the alcyonaria were represented by the organ pipe coral, a tabulate form, and a number of other genera that have not yet been worked over but which are quite distinct from the familiar forms of the Atlantic. Among the mollusks were such forms as *Tridacna, Pteroceros* and *Haliotis,* all of which are rare or wanting in the Atlantic. These are, of course, but a few of the characteristic genera but enough to indicate the fact that along with a great generic identity of forms there are a good many types in the South Pacific that seem to be lacking in the tropical Atlantic.

Another thing that strikes the collector is the almost entire absence of whole groups of marine forms that are particularly abundant throughout the tropical Atlantic. For instance, we found scarcely any hydroids on the reefs and flats about Makuluva in habitats where they would be plentiful in the West Indies. But perhaps the most conspicuous forms about the coral reefs of the West Indies, the gorgonians or flexible corals that abound everywhere we have worked in the Atlantic, are utterly lacking, so far as our collections show, on the Fiji reefs, where their place is taken by flabby, lobulated Alcyonacea that lack the axis cylinder characteristic of the Gorgonacea. While echinoderms were evidently plentiful, the number of species was few, particularly among the star-fishes, serpent-stars and sea-urchins. Such familiar genera as *Oreaster, Asterias* and *Archaster* were apparently absent about Makuluva. Of the ophiurian forms, we found no representatives of *Ophiura,* for instance, and there seemed to be a complete absence of simple-armed basket-fish. Among the Echini proper, the genera *Hipponöe, Toxopneustes* and *Cidaris* seemed to have no representatives on these reefs, and but one crinoid was found. The holothurians on the contrary were plentiful both in individuals and species, although here, too, most of them were of the same genera as found in the West Indies, such as *Stichopus, Euapta, Holothuria,* etc.

Taking it all in all the Makuluva reef fauna was not as rich as that found around many of the West Indian islands, particularly the Bahamas, although the fact that we spent all of our time in one locality may account for not finding a good many things that are probably there.

One thing that struck us as a decided difference between the general aspect of the two regions was the matter of color. Blue is a rather exceptional color, so far as the fauna of the tropical Atlantic is concerned, but is quite common on the Fiji flats. There are many intensely blue reef fishes; the commonest star-fish is a big blue *Linckia,* while some of delicately branching millepores are a very clear intense blue. The tips of the branchlets of several profusely branching species of *Acropora* are of a bright lavender ranging from a bluish pink to a pure blue tinged with pink. Some of the alcyonarians have a distinctly bluish-gray tinge. Of course, there are many other brilliant colors among the reef inhabitants and it cannot be said that blue predominates; but it is much more prominent than about the West Indian reefs.

The most brilliantly colored animals that we saw were found among the nudibranch mollusks, some of which were as gorgeous as can be imagined.

In the following survey of the reef fauna I merely attempt to give some idea as to the general facies of the region from a zoological standpoint, pausing occasionally to dwell upon some of the more interesting forms. The identifications are usually merely approximate, unless otherwise stated. In the descriptions of some of the more striking animals, I have preferred to work independently rather than to look up the descriptions of other naturalists. In this way I hope to impart in the forms discussed an interest that would be lacking if numerous references were cited.

THE FISHES

Carcharius melanopterus. This is the "devil shark," the capture of which was described in the last chapter. In color it is a light greenish-brown, almost white below, the tips of the fins abruptly black, and this color also edges almost the entire tail, especially below. The specimen captured was a young one between four and five feet in length. According to our Fiji reef man they grow much larger and are dangerous to man. We were surprised to find it very good eating, one of the best fish that came on our table while at Makuluva.

The Murænidæ, or morays, were quite common on the flats and we saw several during an hour's walk when the tide was out. They slithered through the shallow pools with remarkable agility and we were constantly being astounded at the small size of the holes and fissures that they were able to enter. There were evidently a good many passages under the flat surface of the rocks as one of these eels would slip into a small crevice and often emerge some distance away. Many of these morays are protectively colored and assimilate well with the surface and rock masses. The larger ones are really formidable animals and more fearless than any other fish that I know. An incident illustrating this point is related in my "Barbados-Antigua Expedition", page 178. We made no attempt to secure the larger specimens on account of our limited space. The following species may be noted:

Gymnothorax. This is the largest specimen brought home by us, being a little more than three feet long. It seems nearest my namesake *G. nuttingi* Snyder from the Hawaiian Islands; but instead of having light spots on a dark background it has very dark, almost black, spots on a yellowish background. The mottling is very fine, the spots are irregular in outline and decrease in size on posterior parts of the body. The tail coloration in general is much like that of *Echidna trossula* Jordan and Stark, and the tail is not so blunt as in *G. nuttingi.* The teeth are sharp, rather flattened, blades, elongated triangles, pointing backward like the teeth of a saw. In places the mottling seems reversed, being light yellowish on a black background. The spots are nowhere aggregated into dark rounded blotches as in *G. pictus.*

Another moray was much smaller, about 22 inches long and very beautifully marked. It apparently belongs to the genus *Urapterygius,* the fins being confined to the caudal region; the markings are very dark brown bands extending across the dorsal and ventral regions but interrupted on the sides by a light yellowish stripe with many small irregular dark brown spots. The ends of each half-band are somewhat broadened, rounded and contain distinct very light yellowish circular markings, making two rows of light spots on each side of the animal. All of the dorsal and lateral areas not occupied by the bands are light yellow with irregular dark brown spots. Anterior teeth are sharp, compressed with tips curving backward while the posterior teeth are much smaller and blunt. The dentition seems to be intermediate between the genera *Echidna* and *Gymnothorax.* Another specimen has the black half-bands less distinct.

Tetraodon, near *T. acrostaticus,* is a very remarkable form with prominent teeth, like immense incisors, one on each side of its jaw, and each divided from its mate by a sharp fissure. The specimen has no definite spines or bristles, but a number of minute soft papillæ can be seen, particularly on the ventral surface, but less evident on the back and sides. The nasal tentacle is bifid, a generic character according to Jordan. The specimen is about nine inches long, the dorsal and most of the lateral surfaces black or very dark brown with round yellowish spots; the ventral surface is yellow with very prominent longitudinal blackish stripes.

The family Tetraodontidæ, or puff fishes, contains a number of bizarre forms resembling the porcupine fishes, but without the formidable sharp spines of the latter. They can swell themselves up as tight as a drum, on occasion, and appear to use this power as a means of protection. The human analogy is so evident that comment is unnecessary. A larger specimen bears out the statement of Jordan that "the black stripes on the abdomen disappear with age." The papillæ, also, are less evident on the larger and presumably older specimens.

The Diodontidæ, or porcupine fishes, are quite common about Makuluva but too large to justify us in preserving specimens. Alfred speared a big one and brought it in alive so we could observe its enormous powers of inflation. It made a definite grunting sound when irritated and we noted that it had workable eyelids and could completely close its eyes, giving it a very wearied expression. It appeared to be *Diodon hystrix,* a species found in the warmer parts of both the Atlantic and Pacific. We had part of this specimen for dinner and found it fairly good eating.

The little fish mentioned on page 45 evidently belongs to the Scorpænidæ, or scorpion fishes, which includes a number of species with poisonous spines. The "lion fish," so much feared by the Barbadians, is an excellent example. Our specimens have been kindly identified by Dr. Barton W. Evermann as belonging to the species *Sebastapistes laotale.* This genus was first described by Jordan and Evermann,[1] who regard the spine before the eye as characteristic of the genus. The specimens secured by us are small, usually not more than three inches long, but they are venomous looking little villains, and I can well believe that it was one of these that stung me so painfully while we were on the Makuluva flats. The head fairly bristles with thorny spines, particularly the operculum and preoperculum; there are others above and just back of the eye and a pair looking like miniature horns just in front of the upper part of the orbit. There are several fleshy tags about the operculum, nostrils and edges of the jaws which add to the general ugliness of the fish. Its colors are mottled brown and yellowish, resembling the surface of the reef rocks on which it lives. Certainly it is a repulsive looking creature and lives up to its appearance. I know of no other fish of its size that can inflict such severe pain on the uncautious collector as can this little *Sebastapistes.* Dr. Evermann writes me as follows: "This species which you collected is regarded as particularly vicious." Another specimen closely allied to this was considerably larger, measuring nearly six inches.

Among the reef fishes was one greatly resembling the "red hind" of the West Indies as described by Evermann. It is one of the groupers and a finely marked fish. The genus *Epinephelus*

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[1] The Shore Fishes of the Hawaiian Islands, 1905, page 455.

is found in both the Atlantic and Pacific Oceans but the species appear to be distinct. The Balistidæ, or trigger fishes, are characteristic of the reef fauna in both the Atlantic and Pacific, and they were not wanting at Makuluva. One specimen appears to belong to the genus *Balistapus,* with three rows of curious spine-like scales on each side of the caudal peduncle and peculiar plates behind the gill openings. The specimen comes nearest to *B. rectangulus.* The anterior part of the head and ventral regions are greenish-yellow, posterior part of dorsal region and laterally, dark dusky which breaks up into oblique bands passing backward and downward toward the ventral region. The trigger, or dorsal fin, has a very stout spine with a roughened surface behind which is a much shorter and smoother spine to "set" the trigger. The scales have peculiar granular surfaces with smooth edges, the latter giving a diamond-shaped pattern over the whole scaled surface.

A specimen belonging to the Pomacentridæ, or "demoiselles," a family characterized by single nostrils, is grayish in color with five sharply contrasted black bands extending somewhat obliquely downward almost from the mid-dorsal to the ventral surface. Its teeth are incisor-like, but each is finely scalloped on its rounded edge, and is so delicate as to be translucent. The Blennidæ are rather common on the Makuluva flats where they seem to remain between tides in little pools or sometimes in crevices of the rock. They have smooth, scaleless bodies and large, protuberant eyes giving them a curious pop-eyed appearance, which, together with fleshy tags to the nostrils and the eyes, very rough forehead and swollen, almost human lips, give them a comical likeness to humanity.

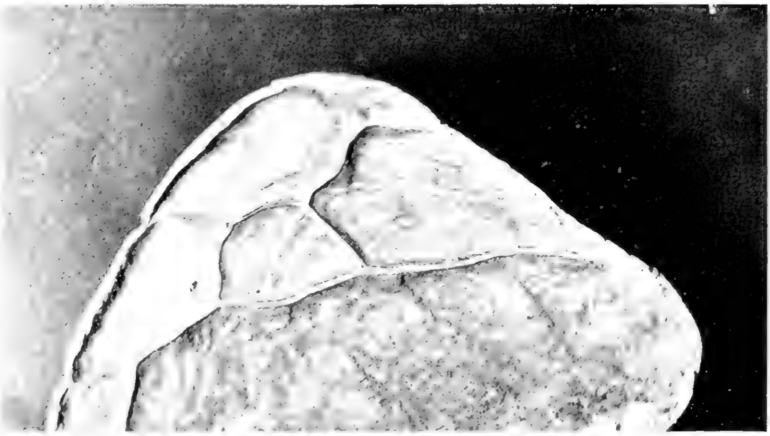
Of course, such a cursory description as is attempted here must omit mention of many forms which will be described in the special reports of the expedition. The present object is to give a general idea of the fauna of the flats and reefs of Makuluva to enable the reader with only a general knowledge of zoology to construct a mental picture of the sort of things he would see if visiting the region.

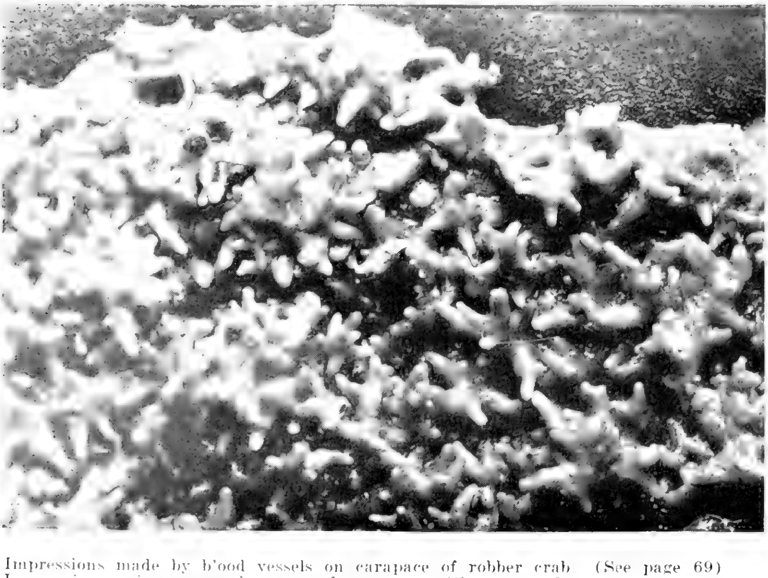
Much might be said of the gorgeous colors of the fishes inhabiting the larger tide-pools near the outer edge of the flats, but it would be impossible to portray in words the beauty and vividness of these colors, the crystal clearness of the water, the fantastic sculpturing of the rocks forming the walls and bottom of

Opened branchial cavity of robber crab The gills are shown above and the branchial papillæ below (See page 68)

Hairy membrane covering gill chamber of robber crab (See page 68)

PLATE X





Impressions made by b'ood vessels on carapace of robber crab (See page 69)
Larger impressions on under part of carapace (See page 69)
Profusely branched pulmonary papillæ lining pulmonary cavity (See page 69)

these natural aquaria, or the festoons and fronds of vivid green, pink and purple sea-weed of various sorts that add to the charm. But there is more than this; one would have to hear the booming roar of the nearby surf, feel the rush of fresh sea air and experience the tang of excitement furnished by the occasional high breaker that sweeps suddenly and most unexpectedly over the slippery rocks on which one stands, before the picture could be completed.

As to the fishes in these larger pools, the most conspicuous and numerous are colored the deepest most vivid blue imaginable, the deep blue of stained glass. They were so wary that we failed to secure specimens and so could not identify them, but they appeared to be blue parrot fishes. An "angel fish," grayish with sharp longitudinal markings, yellow tail, eyes and gills a brilliant blue, was rather common. Then there were gaily decorated butterfly fishes (*Chætodon*) mainly yellow but with sharply contrasting bands and dots of black. Balistidæ of several kinds add their gay reds, yellows, greens, black and white to the general color scheme. Many visitors come from Suva to Makuluva to enjoy these wonderful tide-pools and their gaily decorated inhabitants, which certainly furnish a sight well worth seeing.

Several species of these reef fishes stay between tides in recesses of the rock entirely out of the water. Alfred found an angel fish and a trigger fish in one of the big coral rocks at least two feet above the general surface of the flats that were at the time well above water level.

One of the most interesting fishes we secured does not occur on Makuluva but is found in the mangrove swamps that line the shore of Vitilevu opposite our little island. It is the *Periophthalmus,* or climbing fish, allied to the gobies. This little creature has very pronounced goggle eyes, raised considerably above the level of the top of the head, which it moves independently as it surveys the scenery from a mangrove root well above the water. The pelvic fins are far forward just below the pectorals and united at their bases. They are strong and their inner surfaces can oppose each other in a firm grip. These fins are probably the main agents by which they climb out, hitch themselves along a root or branch and then hold on while they contemplate the world above water. The pectoral girdle is remarkably strong and solid and the pectoral fins can be bent in an abrupt angle which doubtless helps them in working their way between stones or even grass roots. The operculum covers the gills completely and extends well back of them, doubtless aiding in retaining water in the gills when this peculiar fish is out of its native element. The head, with its very large protuberant eyes, resembles that of a grasshopper when viewed in a profile. The two dorsals and the caudal fins are finely barred with red, brown and white, while the paired fins have little or no markings. The mouth is wide and the outline of the upper lip is broken by two prominent lobe-like descending flaps on either side of the middle, giving a most comical expression to its physiognomy. The inner surface of the operculum, which is all in one piece, is covered by a rather thick membrane resembling rubber and reminding one of the lining of the branchial chamber of some of the land crabs of the West Indies.[2]

There is a considerable air space below the gills, between them and the bottom of the head, and below the pharyngeal cavity, which communicates with the exterior by a slit-like aperture, the gill opening; this slit can be closed completely by the operculum. There are four gill arches on each side, each armed by two opposite rows of short gill rakers. The gill filaments are stiff, finger-like projections shorter, proportionally, than in most fishes, a double row supported by each gill arch. There are strong muscles so placed as to allow the vertical movement of the whole of the gills. Each gill filament is divided transversely with various flattened disc-like gill lamellæ looking like a pile of lozenges. The structure is much like that of the gills found in the chitons. So long as these gills keep moist they can perform their function and are, I suppose, capable of utilizing the air either in or above the water. The whole contrivance suggests that a considerable amount of water is kept in the bottom of the large space below the gills proper which is so conspicuous a feature. The rest of the gill cavity might contain air when the creature was out of water. Now the musculature seems adapted to lower the whole pharyngeal apparatus so as to dip the gills into the water from time to time and then lift them again into the air which fills the upper part of the chamber and which can be renewed as often as necessary through the mouth. Thus the moistened gills can take care of the air by the ordinary process of respiration, as all of the necessary elements are present—the thin walls of the gill lamellæ

[2] See Bahama Expedition p. 97 and Barbados-Antigua Expedition p. 183 for a discussion of the adaptations for breathing found in the land crabs of the West Indian region.

being undoubtedly capable of acting as a medium for the exchange of the oxygen in the air outside for the carbon dioxide brought by the blood to the gill lamellæ. The gill filaments, moreover, seem stiff enough to prevent their matting together when out of the water. There is quite an evident analogy between this apparatus for breathing air and that of the land crabs. In the latter the water contained in the bottom of the branchial chamber is applied to the gills by a brush-like modification of the scaphognathite or "bailer," while in *Periophthalmus* the gills, if I am right in my interpretation of the muscular structure, can be periodically dipped into the water at the bottom of the chamber analogous to the branchial chamber of the crab.

The preserved specimens were not suitable for the study of the swim bladder, nor am I sure from a somewhat hasty examination that they have this organ in functional form. This little fish must spend a good deal of time out of the water and seems quite intent on contemplating the scenery. Professor Thomas, who secured the specimens we brought home with us, says that the Fijians call this climbing fish "tiloko." He adds, "It moves over the water by a series of short rapid jumps, can climb up out of the water on to the sticks and stones and stay there ten minutes or more. It is very hard to capture. Two of them jumped out of a pail on the floor of the house and it took Glock and myself several minutes to catch them. It was like catching lively crickets."

In their "Fishes of Samoa"[3] the authors say: "It (*Periophthalmus*) abounds especially in muddy bayous, freely leaving the water to climb bushes, to skip through the grass or to lurk under piles of stone to await the returning tide. It is exceedingly quick of movement and very tenacious of life. Specimens placed in a pail of formalin escaped when the lid was raised."

Most of the members of the family to which this strange creature belongs, the Gobiidæ, are dwellers along the rocky flats and shores that fringe the tropical islands of the Pacific. When the rocks are bare at low tide these little gobies slither across the surface of the flats with remarkable agility and retreat to the crevices and cavities in the rock masses where they often, perhaps habitually, remain until the return of the tide. Thus they have gradually developed an ability to travel rapidly over bare ground and to

[3] Fishes of Samoa, Jordan and Seale, 1906, p. 394.

respire without being immersed in water. From such a group it is not at all remarkable that an air-breathing form such as *Periophthalmus* has been developed.

In his work ''Fishes'' Jordan says, ''In some fishes the eye is raised on a short fleshy stalk and can be moved about at the will of the fish. It is said that the vision of the pond-skipper, *Periophthalmus,* when hunting insects on the mud flats of Japan or India, is equal to that of a frog.''

THE CRUSTACEA

Most of the forms secured were well known shallow water and reef dwellers and members of widely distributed genera, but they are always interesting on account of their marvelous adaptation to environment in form and color. Like the insects on land the crustacea represent a highly successful type of animal and, therefore, a highly adaptive one. They lurk in the crannies of the rocky flats and retreat into the cavities of the masses of coral rock that dot the surface. They are hidden in the fringes of algæ and other aquatic plants that line the edges of the tide pools and hide in the forkings of branched coral heads and alcyonarians. Indeed, they are nearly ubiquitous but usually not at all obtrusive, their retiring disposition being aided by an amazing ability in the way of camouflage, an art at which they were adepts ages before humanity discovered its use. Our Fiji boy, Esile, was adept at catching crabs and many of our specimens are due to his keen eyes and agility, as well as to his patience in breaking off chunks of coral rock in order to lay open the retreat of their crab population.

The writer is indebted to Dr. Mary J. Rathbun, of the United States National Museum, for the identification of the brachyuran crabs mentioned in this brief account of the reef forms, and to Dr. Waldo Schmitt for that of the few macruran forms mentioned.

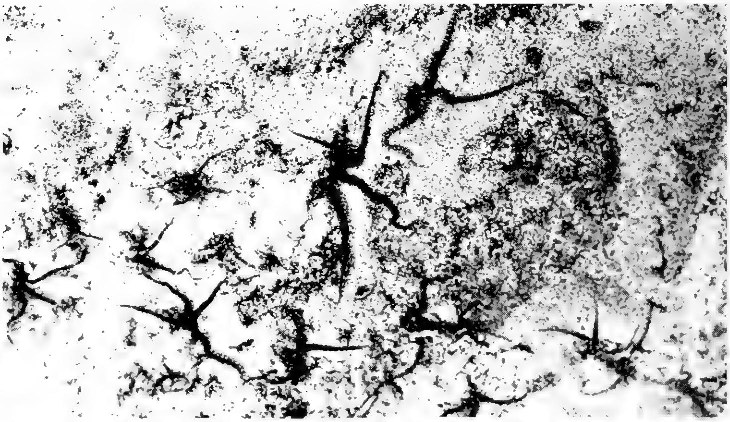
A very smooth-shelled form, *Carpilius convexa,* has a shiny, polished carapace without grooves or lateral spines, but it is very finely punctate. It is creamy white in color with curious scarlet blotches, often amœboid in form. There is a central conspicuous blotch with two plainly marked, eye-like dots of whitish.

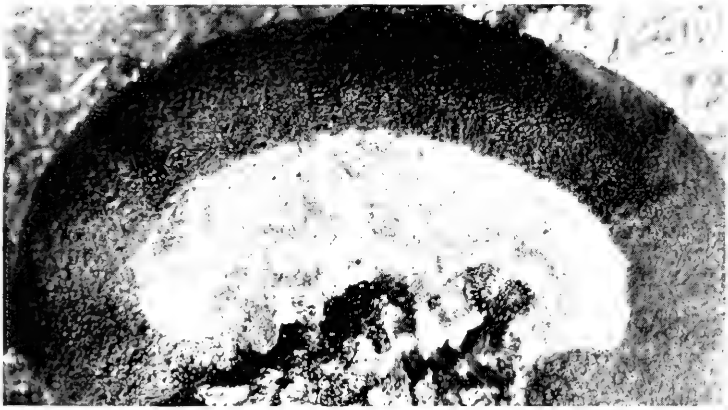
Another form of crab found is *Zozimus æneus,* brick red on the dorsal surface which is strongly carunculated, like a cobblestone pavement. The chelæ have a tuberculate base and smooth olive greenish fingers.

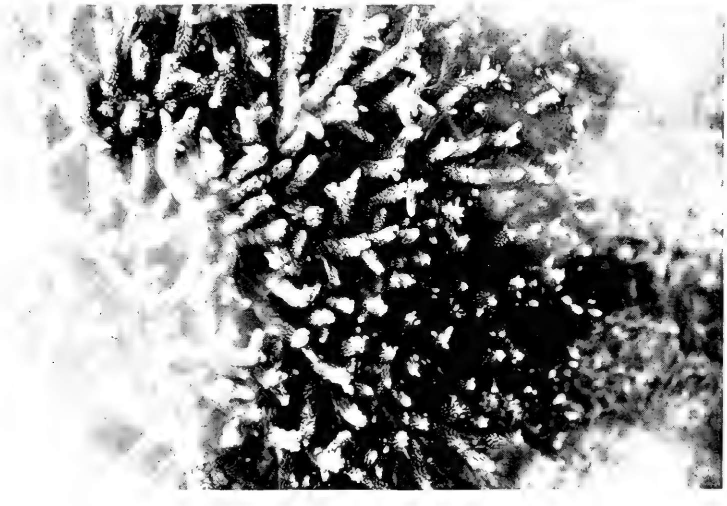
PLATE XI

Periophthalmus, or climbing fish (See page 61) Porcupine fish (See page 59) (Photo by Stoner)
Sebastapistes, a fish with a very poisonous sting (See page 59)

PLATE XII







Serpent stars on Makuluva flats (See page 44)
Expanded coral polyps, probably *Orbicella* (See page 44)
Branching coral The tips are violet pink in life (See page 44)
(Specimens photographed under water by Wylie)

A small land crab, *Ocypoda ceratophthalma,* was found on the sand beaches and also on the higher ground of Makuluva. This is quite a lively little crab that burrows in the sand but spends a good deal of its time wandering over the grass and among the fallen leaves under the trees. It is daintily colored, being very nearly a cream color in general; but the background on the carapace is conspicuously marked near its hind margin with a pair of scarlet blotches which tend to coalesce in the central line but are even there partly divided. The entire carapace is finely punctate. The pointed eye stalks are peculiar and extend well beyond the blackish eye which appears to be merely a basal swollen part of the stalk. The "fingers" are rather slender, thus differing from the truncated ones possessed by the West Indian relative, *O. gaudichaudei.* These forms shed their claws very readily and are so agile as to be hard to capture. Another specimen of this species had very large and prominent black eyes in striking contrast to the general pallid coloration of the carapace.

Trapezia digitalis is a minute crab densely hirsute, reddish in color with black fingers. The hairs are red basally and ivory white toward the ends. The chelæ are very broad and the eyes are small.

Actæa tomentosa is on ovoid form in which the antennæ fold transversely and the appendages are adapted to walking rather than swimming. It is very dark colored, almost black, and conspicuously carunculated; the caruncles themselves are strongly tuberculate. Many of the caruncles are squarish in form and tend to arrange themselves in transverse rows on the carapace. The legs are quite hairy, and the eyes small, flush with the surface, their stalks granulated so as to be scarcely visible when the eyes are retracted. The antennules are mere slender filaments.

The family Grapsidæ is represented by *Percnon planissimus,* allied to the "Sally light-foot" of the West Indian region. This form of rock crab is very greatly flattened and has the art of concealment and of dodging into remarkably narrow crevices, developed to perfection. It is smaller than its West Indian relatives of the genus *Grapsus.* The carapace is densely granulated and a clear dark olive in color. The legs are conspicuously striped with yellow, the distal joints are barred with the same color, showing in sharp contrast to the dark green. There is a group of sharp rostral spines, and the front edges of the legs, particularly the meri, are also ornamented with a row of strong thorny spines.

The chelæ are quite small in the specimens collected, and the eye stalks short. The abdomen of the female is very broad and almost orbicular. In examining specimens after our return the color in some seems to have changed to a dull red.

Of course the universally distributed hermit crabs were abundant on the reefs. This group seems to be a remarkably successful one even if most of its members do live in borrowed homes and pay no rent. The largest and most conspicuous hermit that we collected has been identified by Dr. Schmitt of the U. S. National Museum as *Dardanus guttatus.* This form is very brilliantly colored, even the terga are a very rich crimson, a fact difficult to understand when we remember that the abdomen is habitually concealed in the shell occupied by the hermit. It is noticeable, however, that the abdomen is not so unsymmetrical in this species as in most of the pagurid crabs which may indicate that the hermit habit has been acquired in comparatively recent times. The chelæ and anterior appendages are very hairy, brilliant crimson in color with conspicuous white dots which stand out in a striking manner from the crimson background. The antennæ are very long, slender and almost white in color.

The writer was much disappointed in not securing specimens of the robber crab (*Birgus latro*), although it is found on some of the remoter islands of the Fiji group. It does not occur, however, on Vitilevu where we spent most of our time. An opportunity to study this strange form in its native habitat would have been most welcome as it would have enabled me to fairly complete the study of a series of land crabs illustrating the transition between strictly aquatic and practically terrestrial forms, involving an examination of the respiratory organs of these crustacea which has interested me for a number of years.[4] *Birgus latro* is regarded as having descended from pagurid ancestors which habitually ensconced themselves in gastropod shells, but their descendants have widely departed from the ancestral mode of life, have taken to the shore and even climb trees after coconuts.

We heard the well known story about the manner in which the robber crab is captured by the natives, and it seems to be quite generally accepted in Fiji. The story is that when the native locates one of these big crabs up a palm tree he climbs up part way and fastens a strip or girdle of grass and leaves around the

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[4] See narrative of Bahama Expedition p. 97 and Barbados-Antigua Expedition p. 183 for a discussion of these forms.

trunk and then descends. The crab, in turn, crawls backward down the tree trunk feeling behind it as it goes. When it feels the girdle of leaves it is under the impression that the ground is reached and lets go, tumbles heavily to the earth where it is either stunned or killed. At any rate, it is then an easy matter for the native to catch and tie it up before recovery from the shock of the fall.

Through the kindness of the United States National Museum, this University has been presented with two specimens of the robber crab, one for inspection and return and the other for purposes of dissection.[5] One is a male and measures 15 inches from the rostrum to the end of the tail and has a spread of twenty inches across the back and over the extended walking legs. The total length, including the antennæ, is just twenty-four inches. The antennæ themselves are annulated, like those of the lobster, and the antennules have a bifurcated terminal joint. The carapace, chelæ and walking legs are very curiously ornamented with sharp, transverse, interrupted ridges which are lunate on the cephalic region. The chelate appendages are extremely heavy, especially the third joint which is greatly thickened and trihedral in section. The raised ridges on the hand are broken and there are little tufts of hair in front of each ridge. There are six large walking legs and a posterior pair which is chelate. The abdomen has six well developed terga, the third being much larger than the others. Below the terga the abdomen is in the form of a large soft-walled sack, hairy on the under surface, and is said to contain a supply of oil in the living specimen. Under the distal end of the abdomen is the tergum of the last abdominal segment, bearing rudimentary appendages and the telson. The female is smaller and there are three well developed abdominal appendages on the left side bearing long hairs for the attachment of ova. These three appendages constitute the only departure from bilateral symmetry and doubtless indicate the descent of this form from the hermit crabs.

The most interesting feature of this strange crab, from my point of view, is the respiratory apparatus, especially when compared with that of the land crabs of the West Indies. In opening the branchial chamber of *Birgus* the gills appear, eleven on each side in the ventral portion of the chamber and immediately above the bases of the hinder pairs of walking legs. These gills

[5] The writer takes pleasure in acknowledging the aid of Mr. Wendell Krull, graduate assistant in zoology, in the dissection and study of this form.

cannot be called rudimentary in any true sense of the word, although they are so described by Geoffrey Smith in his treatment of the species.[6] On the contrary, they are well developed. The tip of the posterior gill seems exposed, projecting just back of the last thoracic segment and in front of the last and smallest pair of walking legs. The longest gills measure nearly an inch and a half and are altogether too well developed, it seems to me, for a rudimentary structure. Each gill is terete in form, tapering at each end and attached by its middle to the hard plates which limit the branchial cavity below. There are two series of leaf-like plates on each gill, borne on a hollow stem, the cavity of which is quite extensive in the preserved specimen; this hollow stem communicates with the body cavity at the point of attachment of each gill. It is not quite correct to call this a "hollow stem" because the tube is formed by the union of two series of branchial lamellæ near their distal ends; that is, the members of each pair of lamellæ are thus joined and their extreme bases are also joined so that the "tube" is extraordinarily large, its greatest diameter extending from the extreme bases to near the distal ends of the lamellæ.

The branchial space is divided into a ventral chamber containing the gills and a much larger dorsal chamber lined with branched villi. The gill side of the membranous partition is covered with hairs. Each gill plate is in reality a much flattened hollow sack, like a collapsed water bottle. On the under side of the hollow stem which bears the leaflets is a large number of hairs which under the microscope prove to greatly resemble the "cat-tails" we gather in the fall. Each has a very slender chitinous stalk, the distal part being covered with a dense mass of what looks like the fuzz or fur of the cat-tail.

The membrane lining the entire upper, or pulmonary, chamber is thick and rubber-like and the inner surface resembles short moss owing to the numerous branched finger-like villi that project into the chamber. That part of the membrane immediately around the gills has simple villi that are surrounded by hairs which seem to radiate from the villi. Many of these hairs are somewhat hooked at their ends and interspersed among them are some of the "cat-tail" hairs already described.

The part of the carapace forming the branchiostegite is ex-

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[6] Cambridge Natural History, IV, p. 174.

tensively broken by a series of somewhat deeply incised channels forming a rudely reticulate pattern. On the inner surface of the branchiostegite is a similar network of what appears to be large blood vessels. Inside of this branchiostegite is the highly vascular lining of the pulmonary chamber which bears the profusely branched bunches of villi. The outer surface of this membrane bears complete impressions of the reticulate pattern of blood vessels between the plates. Dorsally these impressions combine to make a very large one running obliquely from the antero-lateral edge of the branchiostegite to the posterior border where it joins a similar impression from that part of the membrane lining the gill chamber proper. The impression made by the combined vessels then turns abruptly inward and forward and seems to enter the body cavity a little to one side of the middle of the line of juncture between the carapace and the first abdominal segment. The hairy membrane covers the dorsal and lateral surfaces of the gill chamber. The number of gills seems to be eleven in both sexes and they lie longitudinally in the branchial chamber.

The condition of the viscera and other contents of the body cavity is such as to preclude investigation of the heart and main vessels.

It is evident that we have in *Birgus* a form more highly specialized for breathing in air than is found in any other decapod crustacean. The quantity of highly branched and vascular villi and the area that they cover is much greater than in any of the land crabs of the West Indies, where gills are still the main organs of respiration. In *Birgus* the gills can by no means be described as rudimentary. Although relatively small, they bear every structural evidence of being functional. The hairs covering the lining of the cavity containing the gills are excellently well adapted to retain whatever moisture there is in the branchial chamber and thus create a condition in which the gill lamellæ can use the oxygen in the air even if there is no water in the bottom of the gill chamber. Doubtless the soft abdomen aids in respiration, as its lower surface is supplied with hairs resembling those in the lower branchial chamber.

I have been unable to learn whether the holes or burrows of the robber crab are deep enough to reach water. In the South Sea islands the general level of the lowlands, especially near beaches, is not far above the water level, and it seems likely that *Birgus* may have convenient access to water to replenish the supply in the branchial chamber without visiting the shore at all. This may, in part, explain the presence of functional gills. In any event it seems reasonably sure that the respiratory tufts of villi are the principal organs of respiration.

This system is evidently derived from that of the hermit crab. A comparison with *Cœnobita diogenes,* a form which is almost as terrestrial as *Birgus,* shows many points of similarity,[7] among which the following may be noted: The gills are of the phyllobranch type and the lamellæ are thicker and less numerous than in water breathing forms. The number of gills is reduced and the individual gills are terete in both species. Similar tufts of hairs are found on the abdominal ventral region of *Cœnobita,* greatly resembling those in the lower branchial cavity of *Birgus,* and channels for blood vessels are found in the lining of the branchiostegite of both forms. The most striking difference is in the presence of the tufted villi in *Birgus* while they are absent in *Cœnobita.* Thus not only the unsymmetrically placed abdominal appendages of the female of *Birgus,* but also the general gill structure, tell the tale of the descent of the robber crabs from the hermit crabs.

Gonodactylus chiragra, one of the mantis shrimps, is quite common on the flats of Makuluva where it is very active. This species has conspicuous black eyes and some of the mouth parts are tipped with scarlet. It resembles the pistol crab in its habit of making a clicking noise when confined in a bottle or glass jar and sometimes thumping the fingers of its captor. As in the common mantis shrimp, the second maxilliped is used as a chela but is built on a different plan from that of the lobster, for instance. It has a remarkably heavy and solid basal joint. The pincer is formed by the backward flexing of the distal joint of the appendage so that it opposes the anterior border of the preceding joint. The inner edge of the flexed finger is very finely serrate, and the teeth are much smaller than in the common mantis. Moreover, the abdominal "hump" so conspicuous in the mantis is not evident in the *Gonodactylus.* Back of the hand there are three pairs of slender walking legs and six pairs of swimmerets, including that of the tail fin. These are very broad

[7] I am using in this connection an unpublished thesis, "Modification of Respiratory Structures involved in transitions from Aquatic to Terrestrial Crustacea", by Otto Walter, a former graduate student in the Department of Zoology, State University of Iowa.

and plate-like, biramous, the exopodite being the broader and edged with hairs. They appear to be much more powerful swimming organs than those of *Squilla,* the common member of the family on our coasts. The last abdominal segment has a very heavy tergum which is strongly corrugated longitudinally; the telson has three similar corrugations proximally and ends in two strong points, one on either side of the median line, with two shorter lateral points on either side of these. The inner borders of the two central points are very finely serrate. The last swimmeret extends backward beyond the telson.

Gonodactylus, much more heavily built and less delicate than *Squilla,* is an inhabitant of the shallow pools on the surface of the flats, and is one of the most common and conspicuous of the crustaceans that we found at Makuluva.

A large crayfish, or spiny lobster, lives in the rocks and shallows around the reefs, but we did not succeed in securing specimens. I suppose it belongs to the genus *Palinurus* which is common in the West Indies and a much prized dainty when properly cooked and served. Crayfish are caught at night by the Fijians who use torches whose bobbing lights could be seen around the island on calm nights at low tide.

One of the notable things about the crustacean fauna of Makuluva is the scarcity of Cirripedia or barnacles. I find no reference to them in my notes nor do I recollect seeing them. These almost universally distributed forms are familiar on all American coasts both East and West, as well as in the West Indian region. We found them later, rather abundantly, on the New Zealand coast.

A very remarkable slender-legged macruran, found in one of the crannies of a coral rock mass, was preserved, but I have been unable to locate it since our return. It was pure white in general color but with blood-red transverse markings on the carapace and appendages. There were blue blotches on the red bars or annulations and the exceedingly attenuated walking legs had numerous thorny processes.

Owing to the scarcity of hydroids and bryozoans on the Makuluva flats, the crustaceans are cleaner than those usually found in such places, not being overgrown with symbiotic organisms.

MOLLUSCA

Here again we find few really unfamiliar forms, a great majority appearing to be generically identical with those found in the West Indies. Perhaps the most striking group at Makuluva was the Nudibranchiata, some of which were among the largest we had seen. Their colors were gorgeous beyond description; scarlet, crimson, white and blue being the most conspicuous. Unfortunately, we were unable to preserve the larger ones and the smaller ones were but sad relics of their former selves by the time they had been immersed in formalin for even a few hours. The colors, of course, are totally evanescent. We doubtless missed many good things among the mollusks on account of not having with us the keen-eyed John B. Henderson, to whom the securing of the fine series from Barbados and Antigua was due. We were practically confined to forms found on the surface and reefs of the flats, as there was no bottom over which a net could work successfully because of the coral heads and rocks. Professor Thomas did the greater part of the work on mollusks, although he had but a few days at Makuluva.

Lamellibranchs were proportionally few and belonged to well known genera. The most conspicuous, of course, was *Tridacna,* which has been already referred to, belonging to a family characterized by the absence of siphons and the presence of a very strong byssus with which it anchors itself to the rock. The specimens on the flats were all small, the deeper water probably being a better habitat for the big fellows.

As I have never seen any detailed description of the soft parts of this giant clam the following notes may be useful. The dorsal edges of the valves are widely separated back of the umbo to accommodate the extraordinarily strong byssus connected with the muscular, cylindrical foot expanded towards its distal end which bears the mass of byssal fibers. The shell has two faint pallial sutures corresponding to the double edge of the mantle which fits closely the deeply scalloped edges of the strong valves. In some specimens the opening for the byssus is unsymmetrical in that the right valve is reflected back over the dorsal surface more than the left. The muscle scars are hardly evident on the shell; this seems strange to one who has noted the power with which the shells grip any intruding object. There is a very large posterior adductor muscle but no anterior adductor, and the attachment of the former to the valves is farther toward the ventral edges than is usual in the lamellibranchs. The muscle itself is enormous and the surface of attachment to the valves correspondingly large. This muscle mass is plainly divided into two parts and the question arises whether these two masses might not represent both posterior and anterior adductors.

The mantle itself is, as already indicated, double edged; the margin nearest the shell is very thin and does not project as far as does the inner border which comes to the very edge of the valves, is very muscular and rugose on its exposed surface where there are also numerous rounded colored tubercles which we took to be eyes like those of the scallop or *Pecten.* The color is completely destroyed by formalin in the case of *Tridacna,* while a good deal of it remains in *Pecten.* On the inside, towards the median line of the body, this muscular part of the mantle sends off a much thinner sheet of tissue which meets a similar one from the opposite mantle coalescing with it along the mid-line so that the whole structure is continuous, except for two rather small, slit-like apertures toward the ends of the gaping shells.

The foot, instead of projecting ventrally as in most bivalves, is turned abruptly towards the dorsum so that the large byssus extends through the great gaping dorsal aperture of the shell. This form being fixed, the foot has no function in locomotion but is highly muscular so as to form a firm anchorage for the tuft of fibers that make up the byssus. The byssal mass seems capable of partial retraction into the foot which accounts for the habit of this clam of shrinking tightly against the rock when touched, so that one can get no purchase with his fingers if he attempts to tear it from its anchorage. The excessively numerous byssal fibers form a compact oval mass of parallel threads about an inch long; each thread is terminated by a flattened cap which adheres strongly to the rock, and the whole mass, deeply embedded in the cylindrical foot, ends in the extensive byssal glands.

Taking it all in all, the extraordinarily developed byssus is one of the outstanding features of *Tridacna.* The portion of the mantle immediately surrounding the byssus and lying between that organ and the opening in the shell is strongly papillose; some of the papillæ branch. The appearance is that of a glandular organ. The labial palpi are poorly developed and hardly distinguishable.

An almost black species of *Lithodomus* was found in holes apparently bored by it in the reef rock. It is almost cylindrical in shape, the umbonal region is smooth, but the rest of the shell, except the extreme posterior end, is very finely crenulated with vertical markings that extend across the lines of growth.

Among the other lamellibranchs were a fine *Pecten,* a few small pearl oysters, a *Lima* and a number of other inconspicuous forms.

The Gastropoda were greatly in the majority among the mollusks of the reefs, many of them being quite conspicuous for their beauty. Many fine Cypræas were collected. One of these, *C. moneta,* has been used as money and is the well known cowry shell. We noticed that a string of these cowry shells was attached to the great kava bowl used by Ratu Popé and we were told that they indicated that the bowl was the property of a chief. There were many specimens of the more showy sort, such as *Cameo, Murex, Pteroceros,* and *Conus.* A very beautiful *Triton* was found, occupied by a large scarlet hermit crab. The shell has very prominent rounded corrugations alternating with quite minute ones. The verrucæ on the whorls are quite distinct but the surface is smooth and one edge is expanded into a ribbon-like border with distinct reddish-brown markings. The small corrugations are broken up into fine nodules in the grooves between the whorls.

Among the Conidæ we found a number of forms, one being the largest *Conus* that I have seen, measuring five inches in length. Unfortunately, however, it was an old and badly worn specimen in which the color markings had been destroyed. Another *Conus* was much smaller, but beautifully marked with rich reddish brown and white scale-like spots of rather irregular form, but each outlined by a dark, almost black, edge, giving a beautiful mosaic effect. Another interesting mollusk was an *Astralium* three inches wide by about two inches high, differing from many Turbos in having quite distinct whorls. The entire surface was covered with fine, closely set frills or ruffles that passed obliquely across the whorls, while the convexities of the ruffles formed lines of prominence arranged at right angles to the ruffles themselves. This curious frilled appearance extends to the lower surface of the shell, almost to the columella, the aperture itself being frilled, except on its columellar side. Another form, apparently a *Trochus,* was abundant and had the solidest operculum I have seen, it being practically hemispherical in shape. We were told that these shells were collected and sold to Indian and Japanese firms for the manufacture of buttons.

Doubtless a conchologist would find numerous interesting things among the smaller and less conspicuous gastropods which we secured at Makuluva, but I am not sufficiently informed to do this. I find, however, the following generic names which are only approximately correct, in my notes, and they may serve to indicate something of the general nature of the gastropod fauna. Those already mentioned are for the most part omitted. I find notice of *Cerithium, Leucozonia, Spondylus, Natica, Bulla, Oliva, Livia, Patella, Haliotis,* and *Mitra.* Many other genera are included in the collection but I do not venture even approximate identification of the smaller things.

I have already spoken of the beauty of the nudibranchs found on Makuluva flats. It would be impossible to imagine more vivid colors than are exhibited by some of them. One particularly brilliant individual gave us an interesting exhibition of swimming in a definite direction by rhythmical undulations of the delicate lateral edges of the mantle. I had read somewhere that the nudibranchs do not swim in any true sense, but positive proof was before our eyes. This specimen was about ten inches long when alive but has shrunk to four inches in the preservative, and, of course, its colors have disappeared.

Many chitons were secured and I find a note of one that was soft and lacked the characteristic plates. A quantity of common forms was collected for future class use.

The cephalopods were by no means so numerous as we found them in the West Indies. A minute *Octopus* was found on the abdomen of a fish. The quantity of ink discharged by a small devil-fish was truly surprising and the agility with which they squirm away from behind their "smoke screen" won our admiration.

ECHINODERMATA

All in all the echinoderms of Makuluva were disappointing. Although numerous enough individually, they were chiefly of well known Atlantic genera and but few surprises were in store for us there. Such forms as *Heterocentrotus* and *Colobocentrotus,* common in the Hawaiian group, were not found, but the ubiquitous *Echinometra* among the echinoids, and *Ophiocoma* among the serpent stars predominated almost everywhere on the flats.

The holothurians, from their size and number of conspicuous forms, were most likely to attract attention. Great, thick-walled species, such as produce the *trepang* of the orient, lie fully exposed in the depressions of the flats. One of the commonest is jet black in color while its dorsal surface is devoid of tubercles, quite smooth and shiny. Our experience in eating it has already been described. It is hard to account for the very conspicuous coloration, as it can hardly be protective unless it is a case of "warning coloration." But the Fijians, at least, consider it good to eat.

The apodous group of holothurians is represented by a fine species, probably *Euapta,* very much like the one described in my narrative of the Barbados-Antigua Expedition. When fully extended it is about two feet long, irregularly mottled brown, reddish brown and yellowish, sometimes giving an effect of obscure annulation. The tentacles are fifteen in number and rather profusely branched. The anchor and anchor plates are much larger than in *Euapta lappa,* often three times as long. The anchor flukes are quite efficient and give a distinctly prickly feeling to the integument, their points breaking off in one's fingers. These spicules are the largest of any I have seen and differ from those of *E. lappa* not only in size but in the fact that the anchors are perfectly smooth, and devoid of nodules on the outer faces of the flukes. They are found in all the Synaptidæ figured by Hjalmar Theil in the Challenger Report on the Holothuroidea. The end of the shank is shaped much like the flukes of a whale and is terminated by fine rows of nodules. The anchor plates, larger and more complicated than those of *E. lappa,* are about as long as the shank of the anchor, and with many more perforations, none of which have the fine denticles like the cogs in a watch wheel. They are shaped much like those figured by Theil for *Synapta beselii* and it may be that our specimens belong to that species which is represented from various islands of the South Pacific, such as Tahiti and the Philippines. As Fiji lies roughly between these two localities it is not unlikely to be found there. This group belongs to a suborder in which the respiratory tree is entirely absent.

The order Pedata has numerous representatives on the Fiji reefs, but lack of space prevents any detailed description. I will, therefore, content myself with giving a few of the color notes from my field notebook. One species was yellowish white with two rows of conspicuous chocolate spots; another was very slender, olive green in color and covered with white spinelike processes; another, a small mottled one, with chocolate and white blotches.

The Echini were numerous individually but not many species were represented. As indicated before, *Echinometra* outnumbered all other forms combined. Its color variations interested us greatly and ranged from almost pure white through various changes of green and olive to a very dark, somewhat purplish brown. Some had distinctly barred spines, and in others the spines were light green with a sub-terminal band of dark brown and pure white tips. The largest specimen of all had white spines while the test was almost black. This species is doubtless *Echinometra lucunter* and is recorded from Fiji in Agassiz' great work, "The Revision of the Echini." Some specimens are quite large for this form. A few *Diadema* were found, and one seemed very much like the West Indian species, although a specialist would doubtless find distinguishing specific characters. Another form which, judging from Agassiz' figures and description, I am inclined to think belongs to the genus *Echinothrix,* is described by him as having spines of two sorts; "the one being very fine elongated silk-like spines and the other large, verticillate or longitudinally striated spines, not as hollow as in *Diadema,* but having more the solidity of those of *Astrophyga.*"[8] This is much like a *Diadema* in appearance, but the two sets of spines are sharply distinguished. The larger set is not characterized by the imbricating whorls of scales so well shown in *Diadema,* but is much more like the ordinary cidaroid type where thin and definite longitudinal rows of denticles are found. These spines are almost as long as those of *Diadema* but are stouter basally in proportion to their length. In one specimen these are jet black, in another they are barred with dark brown and very pale green, almost white. Another set of spines is placed between the larger ones and characterized by extreme slenderness, appearing rather like stiff hairs than spines. These are black in the black specimens and finely barred in the one with the barred primary spines. The actinostome is much like that of *Diadema,* but the buccal feet are more numerous and not so prominent. The apical system also resembles that of *Diadema.* Not daring to denude the test and thus reveal the tubercles, I am much handicapped in studying these specimens which I at first mistook for *Diadema.*

A small form, probably of this same species, shows the buccal feet without plates, a distinct anal cone and a few spines on the plates of the apical system. The distinction between the two sets of spines is not so great as in the larger and presumably older specimens.

Another specimen bears some resemblance to *Strongylocentrotus*

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[8] Revision of the Echini, pl. 111[a], figs. 1 and 2.

as defined by Agassiz, but the pores are not distinctly arranged in arcs of four or five pairs and the peristome has minute and numerous detached plates. The spines seem to be of two kinds, long and short; the former slightly attenuated at the distal end and light green throughout, while the latter are slightly clubbed at ends; the clubbed parts are white. The two sorts seem to intergrade, however, although most of them appear quite distinct.

Only one petalostichan form was found, a small specimen closely resembling *Echinoneus semilunaris* that we collected at Antigua in 1918.

The Ophiuroidea were abundant in the shallow pools on the landward side of the reefs where the water was comparatively quiet. But even here each specimen had an anchor to windward in the form of an arm or two thrust into the narrow fissures of the rock. Thus an entire specimen was hard to procure. *Ophiocoma* was, as usual, by far the most abundant genus, many times outnumbering all others combined. The astonishing variation in coloration continually surprised us. Some were almost entirely black, others black with large white spots in glaring contrast. One had all the spines finely ringed with dark brown and white. *Ophiocoma echinata* was by far the most abundant species. *O. riisei* was also found, although Agassiz in his illustrated catalogue of the Museum of Comparative Zoology does not report either species from the Pacific. *Ophiothrix*, with its glassy spinulated spines, was occasionally seen. It had the pierced jaws, characteristic of the genus, according to Agassiz, the prominent radial shields, numerous tooth papillæ, conspicuous tentacles and bluish green color of *Ophiothrix*. The upper and under arm-plates are blotched or finely speckled with dark brown or black. The spines themselves are not so long, relatively, as in the West Indian forms I have seen. *O. longipeda* and *O. demersa* are the only species reported by Agassiz as occurring from the tropical Pacific, and these do not agree in specific characters with our specimens, which may belong to several species.

Another serpent star has a very close, superficial resemblance to *Ophiura;* the upper arm-plates are broken up as in *O. cinerea*. The barred arms, short arm-spines, scaled disk, slit-like genital openings just outside the mouth shields, two tentacle-scales and numerous papillæ are characteristic of the genus. But the resemblance is superficial only, so much so that a careful study convinces one that it cannot be an *Ophiura* at all, according to

Agassiz' definition of that genus. In the first place there are but two genital openings to each arm, instead of four, although the two present are very near the mouth shields and on the side of the arm-base instead of in the interbrachial region. The arm-spines are but three in number, instead of seven to thirteen; the spines are not noticeably flattened and stand out from the side arm-plates resembling relatively small spines of the *Ophiocoma* type. The disk is covered with minute, scale-like plates and the radial shields are so small as to be scarcely evident. This interesting form does not fit into any genus described by Agassiz. Other closely allied specimens may belong to the same genus.

Another specimen, which I have been unable to identify generically, has a jet black disk and white arms with almost white spines, sharply speckled with black, cylindrical in form, and abruptly truncated at their distal ends. It looks like an *Ophiocoma* and has evident mouth papillæ. The disk has a leathery, granulated integument typical of that genus. One specimen mentioned in my notebook had a spread of about two feet, the greatest I have found among the true serpent-stars. It was grayish in color, with very prominent radial shields and may have been an *Ophiothrix.*

The Asteroidea were poorly represented on Makuluva. By far the most common was a large, intensely blue species, one of the most conspicuous objects on the flats. Dr. Stoner found one in a New Zealand museum labeled "*Linckia lævigata.*" It is a large, pentamerous species, usually with a spread of a foot or more, and sometimes individuals are found with more than five rays. The disk is quite small compared with the length of the arms. The color, an intense bright blue, disappears rapidly when specimens are dried but much less rapidly in alcohol. It has a tough, leathery consistence and rarely if ever shows the tendency to shed its rays, so remarkably manifest in West Indian species of this genus. The surface is quite smooth, although close inspection shows that it is finely granulated. Papulæ are numerous on the dorsal and lateral surfaces, but not on the ventral surface below the marginal plates. The latter are arranged in two regular rows which are evident but not conspicuous. There is a single row of short stumpy spines on either side of the tightly closed ambulacral furrow whose surfaces are granular like that of the general surface of the starfish, and they seem to be covered with a rather thick integument. The tube-feet are provided with suckers and are arranged in two straight rows in each ambulacral area; the ampullæ are leaf-like. No pedicellariæ can be seen. There is a single, very flat, round madreporic body. The autotomous species of this genus, such as *Linckia guildingi* found in the West Indies, have more than one madreporic body.

A small specimen, grayish in color, with a relatively large disk and short triangular arms, was found on the tide flats. It has a conspicuous row of marginal plates representing the upper marginals, but the inferior marginals seem to be lacking. The upper series bear conspicuous triangular spines and there is a row of short pointed spines covering the ambulacral groove. Beneath these, as viewed from above, other rows of fine spinelets are found. The thin, fragile dorsal plates are regularly arranged, while the madreporic body is inconspicuous and pedicellariæ appear to be absent. This form greatly resembles *Gymnasteria carinifera* as figured by Sladen.[9] He names the Fiji Islands as one of the localities from which this species is reported and states that it has been found on the reefs there.

I find in my notes the mention of a "fine sessile crinoid with arms barred brown and white." This is the only crinoid we saw while at Fiji, and it so disintegrated in the preservative used (formalin) that I will leave it for description by a specialist when the scientific results of the expedition are worked out. Of course many other echinoderms have been passed over without mention, as this narrative presents merely a cursory view of things that strike the author as having particular interest.

WORMS

This term is used in the old sense to include all worm-like forms, such as leeches and nemertines, as well as the annelids proper. The representatives of this heterogeneous group found on Makuluva are not numerous and do not compare in variety with those secured by the Barbados-Antigua Expedition of 1918. This is due in part to the difficulty of breaking up the flinty reef-rock in order to expose the forms hidden in the deeper recesses.

Among the Polychæta is *Leodice longicirrata*.[10] This specimen is the longest true annelid I have ever seen, the preserved spec-

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[9] Asteroidea of the Challenger Expedition, pl. LII, figs. 5-8.

[10] Miss Catharine Mullin of the Department of Zoology in the State University of Iowa has been good enough to identify approximately the forms here mentioned.

Hon. T. E. Fell, C. M. G., Colonial Secretary of Fiji
A powerful friend of two expeditions from the State University of Iowa

PLATE XIV

View of part of Suva and Suva Bay from Fiji Club (See page 89)
The Fiji Club house (See page 89)

imen being forty inches in length, with the terminal part of the caudal end missing. The color in life is a rather bright reddish brown which has not been changed greatly in preservative. The gills are rather profusely branched on one side, there being twenty branches on a single gill in some cases, and they are conspicuous organs borne on the parapodia. The setæ are in tufts. The nuchal cirri, characteristic of the family Leodicidæ, are present. The setæ are not so large or numerous as in the "sea scorpions" of Bardados.

Another very slender, dark brown specimen appears to belong to the Leodicidæ. It is darker than the one previously described and much more attenuate.

The Phyllodacidæ are represented by a form having exceedingly conspicuous bunches of setæ. The body is greatly flattened and the sides appear as if covered with cotton wool along their entire length, so numerous are the glassy spicules so compacted together that the parapodia proper are not visible, nor are the segments when viewed from the side. The head bears the caruncle, peculiar to this family, apparently lamellate in structure, and the parapodia bear gills. The setæ are much like those last described, many of them being distinctly serrate on one side of the distal part, while others are exceedingly fine and smooth.

The tube dwelling forms are represented by several species. One seems to belong to the family Sabellidæ which we found so abundant on the sea-wall at the dockyard in Antigua.[11] The tubes feel rather soft like a sponge. The gills are brown and borne on a double horse-shoe shaped lophophore. Each gill seems to have a double series of filaments along most of its length and these filaments are relatively longer and more slender than those in the Antigua species, although the entire worm is much smaller.

Some fragmentary specimens seem to belong to the Terebellidæ. They construct tubes of bits of shell, stone fragments, etc. which look like very crude and badly made mosaic work.

One of the most surprising forms seems to be a nemertine. It is one of the most conspicuously colored worms I have ever seen. When fresh it was nearly a yard long and was pure white in color with a very conspicuous broad longitudinal dorsal stripe of dark, bright, reddish brown. No coloration could be more striking than

[11] Mullin. Report on some Polychætous Annelids collected by the Barbados-Antigua Expedition in 1918.

this combination. The dorsal band is much interrupted in places. The form is flattened and attenuated to a mere thread at one end where there is an appearance of branching into several very slender filaments. On what I take to be the head end, its greatest diameter is about a quarter of an inch; here is a broad collar of the same chocolate brown as the dorsal band and at this end there is some indication of segmentation, although the body in general is smooth. Another nemertine is quite dark brown all over and probably two feet long.

A small marine leech completes this hurried list of some of the more conspicuous worm-like forms from Makuluva; but the specialist will doubtless find others of interest equal to those mentioned above.

CŒLENTERATA

As would be expected, this phylum furnishes the great bulk of animals on and about the coral reefs, and I imagine that it would lead all others in actual number of species.

Commencing with the alcyonarians, we noticed the absence of two of the three groups into which this order is usually divided. We found no representatives of the Pennatulaceæ nor of the Gorgonaceæ; the Alcyonaceæ being the only one represented in our collection. The absence of sea pens, or Pennatulaceæ, is not remarkable as they are usually deep water forms; but the total lack of the flexible corals, or Gorgonaceæ, is much more noteworthy, especially to one accustomed to the multiplicity of these forms in the tropical Atlantic.

One form very closely resembles *Sarcophyton* in general shape, being a good deal like a somewhat irregularly lobed mushroom. The stalk is thick and devoid of polyps while the head is much expanded to form a somewhat kidney-shaped mass on the upper surface of which the completely retractile polyps grow. There are no calyces, at least there is no evidence of them when the polyps are retracted. At first I could find no zooids, but they are evident under the low power of the compound microscope. The polyps themselves are of the ordinary alcyonarian type with eight fringed tentacles which do not close over the disk, and with small spicules. The general cœnenchyma is a spongy mass with numerous, slender, spindle-shaped, warty spicules. There are two specimens of this form in the collection from Makuluva, which agree very well with the figures of the genus *Sarcophyton,* as given by Bourne in his article on Anthozoa.[12]

One of the most interesting forms encountered on the Makuluva reefs was an alcyonarian with *strongly retractile branches,* a thing that I had never heard of, except in some pennatulids, such as *Ptylosarcus,* where the stem is highly contractile, or perhaps it would be better to call it erectile.

The Makuluva form looks so much like a gorgonian, such as *Plexaurella,* with erect stubby branches, that I supposed it was one. One of the surprises of my life came when I touched one of the branches and all of them immediately began to retract until the whole colony took on the shape of an irregularly rounded mass, each branch being reduced to a nodule on the general surface. The retraction was fully as rapid as that of an anemone, and repeated experiments showed that they always quickly responded to a tactile stimulus. The polyps promptly retracted at the same time. An astonishing effect of this retraction is that the colony *turns pale* at the approach of danger—first shrinks away and then turns pale, like a timid maiden! The polyps are dark brown when expanded, thus giving a decided brown coloration to the colony. The cœnenchyma, however, is almost pure white and the retraction of the polyps exposes this surface, resulting in a quick change from brown to white, dotted with the brown openings into which the polyps have withdrawn.

The polyps themselves are small, dark brown, having tentacles of the usual alcyonarian type with fringed margins. They are encrusted with small spicules of a type not at all characteristic of the family Nepthyidæ to which this form seems to belong. These spicules are almost uniformly double spindles, or rather double-stars, such as characterize the family Gorgonellidæ, a widely different group. These double-stars have their ends covered with strong nodules which themselves bear several sharp points, and there is a smooth girdle on the median part of the spicule separating the two stars. The tentacles are not fully retracted but are folded over the disk of the retracted polyps, a character diagnostic of the family Nepthyidæ, according to Bourne. However, the uniform spicules in the shape of double-stars, (for I found none of the spindles) would, it seems to me, necessitate another class-

[12] Lankester, "A Treatise on Zoology", part 2, fig. XII, and the text on p. 24.

ification. Such spicules are found in *Sarcophyton* belonging to the Alcyonidæ, according to Thomson and McKinnon.[13]

In longitudinal section the canals are parallel but branch near the surface to connect with the numerous polyps and are almost filled with ova which are often found a considerable distance below the surface. The partitions between the canals bear numerous spicules, which would indicate that the species belongs to the sub-family Siphonogorginæ; but I find no report of double-stars in this group. A cross section of a branch shows no large central canal or group of canals but the walls are thicker than usual, probably from the necessity of accommodating the muscular masses that effect the retraction of the branches. In a retracted colony such a cross section shows the water tubes occupied by tissue which seems continuous with the polyps and may be muscular.

Another alcyonarian found aboundantly on Makuluva flats belongs to a family that I have not met with before, the Xeniidæ. The colony is encrusting or irregularly lobate, a clear reddish gray, almost violet, in color and lives in the shallower tide pools of the flats. Often the bodies of the polyps are almost white and the tentacles gray. In some cases the polyps are entirely white. They are non-retractile, a characteristic of this family, hence this form is an admirable one to preserve for class use. The polyp bodies are translucent and about one-half inch long in the living specimens. The tentacles are strong and have a close-set fringe of stubby papillæ on either side, with two or more rows on each side of a tentacle. In certain views the papillæ appear to cover the upper surfaces giving the appearance of closely set knobs. The tentacles and papillæ are frosted over with numerous minute spicules which are round or oval disks with a granulated appearance, and shaped like red blood-corpuscles. These spicules are also numerous on the thin polyp walls where they are closely and evenly scattered. These disk-like spicules are also characteristic of the family Xeniidæ. Although they are most abundant on the surface, some of them are seen scattered throughout the fleshy cœnemchyma. The polyps are so packed together on the surface as to leave very little room between their bases.

A longitudinal section of a branch or lobe shows the numerous canals which are continuous with the body cavities of the polyps

[13] Report on the Percy Sladen Trust Expedition to the Indian Ocean, pl. 13, fig. 12.

and which contain mesenterial filaments extending considerably below the general surface, ova and developing planulæ quite down to the base of the colony. Siphonozoids seem to be absent in this species, although very small young polyps are found near the bases of the fully grown ones, from which they appear to be budded, near the surface of the colony. These could easily be mistaken for siphonozoids, as suggested by Wright and Studer in their Report on the Alcyonaria of the Challenger Expedition.

The only other alcyonarian that calls for mention is the organ-pipe coral, or *Tubipora,* which we saw here in a living condition, a new experience for all of us. We preserved some of the smaller colonies, showing partly expanded polyps, for subsequent study. But this beautiful form has so often been described and figured that it need not detain us now.

Most of the reef corals have been mentioned in the preceding chapter. Dr. Vaughan has been good enough to name most of the genera represented by our collection of dried specimens. In the Challenger Report on the Reef Corals, John J. Quelch enumerates sixty species from Fiji, the largest number found in any one group of the Pacific Islands, according to these writers. Doubtless others have been added since.

By far the most conspicuous genus is *Acropora* which contains most of the larger branching forms. Some greatly resemble *A. alcicornis* or the staghorn coral of the West Indies. One very beautiful species seems to be the Pacific representative of *A. palmata.* It forms a kidney-shaped horizontal plate, usually quite symmetrical, about eighteen inches wide. From this plate arise numerous closely crowded vertical spikes about three-fourths of an inch high, all attaining approximately the same level. The upper surface of the colony is slightly concave. Viewed from below, the corallum is seen to be composed of a mass of anastomosing branches forming a flabellate structure that appears like a solid plate when viewed from above; but below it is a mass of branches which anastomose very profusely. The tip of each of the vertical spikes is colored a bright bluish pink while the rest of the colony is a grayish brown. It grows in the quieter pools inside the reefs. There are several species of this wide-spread genus. One forms a clump of short, stout branches, the corallite walls being unusually thick and the margins incomplete on the adaxial side, so that the ends of the corallites look like horseshoes with the convex sides turned downward. Another species, similar in form, has corallites of much smaller size.

The genus *Pocillopora* is represented by several finely branched species. The colonies are generally smaller than those of *Acropora,* but there is great diversity in the manner of branching. The most common form is a dense oval clump of closely aggregated branches; but sometimes they are delicate and slender like the common *Acropora* of the Atlantic.

Fovites is a genus that I had not seen before. It seems to be an encrusting form, and the general aspect is like that of some of the Devonian fossils. The corallites are low and large, quite varied in shape, their walls contingent; in combination they form a sort of network of large mesh. Our specimens greatly resemble the figure of *Cyphastrea ocellina.*[14] *Leptoria* is another genus greatly resembling *Meandrina* of the tropical Atlantic. The corallites are extensively confluent and the septa all seem to belong to one series, instead of two as in the Atlantic *Meandrina. Turbinaria* is a foliaceous form with distinct round corallites separated by cœnenchyma, sometimes of considerable extent. *Porites* is another genus well represented on these reefs, but the specimens offer no important points of difference from the West Indian forms.

While on Makuluva I tried preserving coral polyps in an expanded condition by a method that Dr. Vaughan has used successfully. My chief difficulty was getting them to expand in the laboratory. This they refused to do, although I tempted them with choice bits of crab meat which Dr. Vaughan informed me was eagerly devoured by the Atlantic forms with which he experimented.

The *Orbicella* mentioned on a preceding page was of intense interest to all of our party, as it offered a display of expanded polyps unique in our experience. These were brown but had a white area around the mouth.

The anemones were represented by a number of interesting species. I have already spoken of the huge specimen that had a spread of something like eighteen inches, the largest any of us had ever seen. It had an extensively lobed, fringed disk margin and thousands of bright green tentacles. The body beneath the

[41] Vaughan, Recent Madreporaria of the Hawaiian Islands and Laysan, pl. XXVI, fig. 1.

tentacles was a beautiful orange red. It bore considerable superficial resemblance to the figure of an actinian given on pl. 4, fig. 31 of Dana's Zoophytes of the Wilkes U. S. Exploring Expedition. These plates still remain, in my opinion, the most beautiful ones, of anemones, that I have seen.

Great areas of the flats were fairly carpeted with colonial anemones or Zoanthidea. I suppose there were literally acres of them and doubtless some colonies contained thousands of individual anemones. They were rarely expanded at low tide, even when covered with water, so we could not get satisfactory views of the polyps. They were usually of a yellowish tan color, sometimes almost buff. In preserved specimens the polyps are thickly crowded over the surface leaving but little cœnenchyma exposed, and they are but little exserted; their walls are tough and leathery, having a sandy feel, for this form and many of its allies cements sand on its outer surface, presumably for protective purposes. The mesenteries are numerous, about forty in specimens examined, and are furnished with thick muscles. The tentacles are folded over the disk in retraction. A vertical section shows that the polyp is about one centimeter long when retracted.

Several other anemones were found, both compound and simple, but the two described were by far the most conspicuous. My notes mention a slaty blue compound anemone, and we brought a number of other forms which will be placed in the hands of specialists.

But one medusa was seen by me on Makuluva and that was too large for any of our bottles. It was of the Rhizostomæ type with complicated mouth-arms and no central mouth. The disk was purplish in color, the lower part blue, the mouth arms transparent and brown-edged. The hydromedusæ were inconspicuous, with the exception of the Hydrocorallinæ of which several species were fairly common. One that closely resembles the *Millepora* of the West Indies was identified as *Psammocora* by Dr. Vaughan. The colony forms a profusely branched clump, the tips of the branches often having a clavate form. The surface is quite unlike that of *Millepora,* however, being covered with curious, densely aggregated, bristly points and short bristly ridges, which in some places give a minutely vermiform appearance. The zooids are hard to make out. The gastropores are placed in the center of a number of bristling radiating ridges which are shaped like the petals of a flower, forming a sort of daisy pattern around the gastropores.

These tend to a linear arrangement in very shallow grooves on some parts of the surface. The dactylopores are arranged around the gastropores and between the petals. There is evidently a style to each gastropore. The largest colony secured is about seven inches high and profusely branched.

Distichopora is represented by small branched colonies. The branches are rounder than in specimens from the Atlantic and have a purplish tinge. The edge of each branch has a deep groove along its whole length and the gastropores are arranged along the bottom of the grooves, while the dactylopores occupy the ridges on either side. The general surface seems to be largely devoid of the blister-like swellings found on our West Indian specimens. A majority of the specimens collected at Makuluva are a pretty blue, rather than purple, almost the color of the large starfish *Linckia,* although a somewhat darker blue, and the tips of the branches are often almost white. Some specimens have the short, stubby branches on opposite sides and strictly alternate. None of them is over two inches in height. In addition to the gastropores and dactylopores along the grooves on the edges of the branches, there appear to be others on the surfaces and in one specimen at least the zooids themselves are seen in a regular cyclosystem. This would doubtless place the species in another genus, a description of which I am unable to find.

We found no ordinary hydroid colonies at Makuluva. This is, I believe, the first place where I have failed to find material belonging to this group.

Numerous sponges were also found, but nothing that seems to be worthy of special mention.

CHAPTER V

OUR EXPERIENCES ON VITILEVU, FIJI

The Fiji club was a welcome relief after the somewhat strenuous life at Makuluva. There was a comfortable writing room where we could bring our notes and correspondence up to date or read the latest papers from New Zealand, and others which were about a month old, from England. I saw no papers or magazines from the United States and we were thus completely isolated, so far as home news was concerned.

About five in the afternoon the club members, almost all of them colonial officials, assembled for a social hour or two before dinner. As seems almost universally the case, the colonials are not teetotalers by any means, neither were they worried by prohibition laws.

The house servants were Indians, in red fez and white coats, and they were quite efficient. We were somewhat surprised to note that the doors and windows of the club house were always open, even at night when the lights were out and everyone sound asleep. This denoted a sense of security from thieves that was novel to us, especially in a city as large as Suva; but the club officials assured us that there was no danger of anything being stolen, so sure were they of the honesty of both the Indians and native Fijians. Indeed, the only case of thievery we knew of was when some money, a silk scarf and other small articles were taken from Glock's room when we stopped at the Grand Pacific Hotel just after landing. This we attributed to the fact that this hotel was the most thoroughly Europeanized house in Fiji.

My most interesting experience in Vitilevu was a visit to Ratu Popé of Bau, who, Secretary Fell assured us, was the most powerful of the present Fijian chiefs. The trip was arranged through Mr. Stewart who was, I understand, the Secretary of Native Affairs under the Colonial Government. I had also a personal letter of introduction to Ratu Popé from Secretary Fell. An American railroad man, Mr. Welch, with some other tourists, chartered a launch for a trip to Bau, and through their courtesy I took advantage of this arrangement instead of trying to get a

Government launch for the purpose. When I went on board, about noon, I found quite a gay party of excursionists who had provided plenty of eatables for us en route. The inside passage between the reefs and the coast was very rough; the waves often dashed masses of spray completely over the top deck of the launch and thoroughly drenched a few adventurous young folks who were riding on top. Canvas curtains from roof to gunwale on the windward side protected those below fairly well, but considerable water came in. We ate lunch during the roughest part of the trip, but all were good enough sailors to enjoy it in spite of the violent antics of the boat.

We passed Makuluva on our right and took a short cut through mangrove swamps to the Rewa River, the largest stream on the island. The jungle of mangrove trees on their network of roots, which rose well above the surface of the water at low tide before they united to form the gnarled and twisted trunks, formed an impenetrable mass on either hand. The oddly shaped branches sent down innumerable shoots to the muddy ground; these in turn took root and thus formed a perfect maze of interlacing roots and stems making an impassable barrier, the gloomy depths of which were overshadowed by the dense dark green foliage through which scarcely a ray of sunshine penetrated. In the ooze beneath, many crabs of various kinds found home and livelihood, while the peculiar climbing fishes, *Periophthalmus,* were perched on the roots above water calmly surveying the scenery with their protruding, goggle eyes.

We ascended the broad stretches of the Rewa River for several miles. On the right bank we saw an imposing group of buildings at Naililili where there is a large Catholic mission and church. About sixty square miles of good, arable land have been formed by the Rewa delta; indeed this seems to be some of the best agricultural land in Vitilevu.

Shortly after this we turned abruptly into a muddy channel, said to have been dug originally by some of the war-like Fijians of a former generation, whereby the natives of Bau could quietly transport war parties to attack the tribe on the Rewa; from these forays they often returned with ''long pig'' to furnish the *piece de resistance* for a cannibal feast. This channel is narrow and tortuous, much like a very muddy winding creek at home; we frequently ran our bows into the bank and had to back off, as the tide was low. Here and there we passed small Fijian villages of grass-thatched houses, usually of one room, with no opening but a single door. These villages became larger as we advanced, and groups of people could be seen, some of them with no clothing but a narrow strip called the "sulu." Children were quite in a state of nature and the women retired modestly to the background as we passed. There were a few trees such as mangos, coconut palms, bread-fruit trees, etc. in each village, and small garden patches which seemed common property were in evidence.

At about four in the afternoon we reached the west coast of the island; the sea was not rough and we had a pleasant run of eight or ten miles past occasional picturesque islets on our right, some of which were quite rocky with eroded shore-lines. It was almost sun-down when we reached the island of Bau, one of the most historic places in all Fiji, and very picturesque it was with hilly contour and many trees of kinds strange to us. We stepped from the launch onto a rickety pier and were at once surrounded by a group of Fijians, not one of whom appeared to know a word of English. However, our skipper found a boy who agreed to deliver my letter of introduction to Ratu Popé and I saw him go to a group of men, kneel and deliver the letter to his chief. Meanwhile, we waited until the lad returned and motioned me to follow him. We found the chief playing cricket with the Bau Cricket Club in which he takes great pride. With a pleasant greeting in excellent English he asked me to be seated for a few minutes until the game was over. Then he had my suit case taken to his home and arranged for the rest of the party who were to be accommodated at the rest house.

Ratu Popé is a very handsome man, speaks English as well as any of us, is a member of the Executive Council of Fiji and absolute ruler of this little island with a population of about seven hundred happy looking natives. I find in the account of the Wilkes expedition that in 1840 "Ambau," which was the old spelling for Bau, was the most important district in Fiji and had a population of about 6,000 people, not confined, however, to the island itself. Ratu Popé is a grandson of Cakobau, the last king of Fiji, and says that he is in all probability the last of his line. I have never experienced finer courtesy than while a guest in his home. The house itself is of the same pattern as the rest but much larger. It has but one room, about twenty by forty feet. The floor is covered with fine matting and the walls made of slender reeds, bound together with sennit on the inside and thatched heavily with leaves on the outside. Everything was scrupulously clean. Inside was some European furniture such as a table, a few chairs and an oil lamp. This table is historic as it is reported to be the one on which was signed the document which turned the islands over to the British through King Cakobau. There were a few pictures on the walls and, contrary to the usual custom, there were several windows in addition to two or three doors. The chief wore the native sulu consisting of a rectangular piece of white cloth about the size of an ordinary towel simply wrapped around the loins and tucked or rolled in at the waist. He also wore a white shirt with a collar and neck-tie, but no shoes while at home; however, he wore the regulation European clothes while on official duty at Suva. We ate alone at dinner attended by a man servant. No native woman entered the house while I was there. We had soup, chicken, vegetables and very good coffee. Afterward he seemed to enjoy one of my cigars and we had a delightful chat in which he showed considerable acquaintance with world affairs.

Ratu Popé then invited the other visitors to join us in a kava drinking ceremony which partook of the nature of a solemn ritual. Kava, a drink known all through Polynesia, is made from a root called "yangona." The fibers are separated by pounding in water so that the juice is extracted and they are then strained out with an instrument resembling a bunch of fine twigs. The remaining liquid is whitish or milky and has an aromatic twang, rather bitter and peppery. At the ceremony in the evening I was seated at the right of the chief and the other visitors sat along the sides of the room in chairs brought for the purpose. Near the center of one end of the house, opposite most of the visitors, was the kava bowl about three feet across supported on short wooden legs, shallow, like a great wooden soup plate. The men who were to take part sat cross-legged back of the bowl. A string of cowry shells stretched out from the front indicated that it was the property of the chief. The main functionary, himself a subordinate chief, took a kava cup made of the half shell of a coconut, stirred the fluid solemnly for a while, then filled the cup and handed it to a second man who, kneeling, gave it to the visitor regarded as the guest of honor. The recipient took the cup, which is almost as thin as an egg-shell and pointed at the bottom, in both hands. Etiquette required that he empty the cup at one draught and then spin it on the floor by a dexterous twist of the wrist. At the same time all the men clapped their hands rather slowly and solemnly and cried, "matha" (it is empty) in a low voice. The cup then went the round of the visitors and finally to the native men; but I understand that it is tabu to the Fijian women. This kava drinking is said to last practically all night sometimes, and the greatest decorum prevails. It is regarded as bad form to change the position of one's feet, and as all are seated cross-legged on the ground, the position is no less than torture to an ordinary white man; even the natives, I was told, find it a severe test of endurance. Fortunately, the rules were relaxed in our case and the visitors had chairs.

I noticed no effect to indicate that kava is intoxicating, but was told that confirmed drinkers after a long bout have their legs affected. The taste was not particularly pleasant to the novice, but the effect was distinctly refreshing. Major W. A. Chapple says,[1] "It (kava) has absolutely no effect on the brain or senses. In great excess it is said to weaken the legs, though it does not affect the mind or consciousness. The drink is not pleasant but it has a slightly styptic effect on the mucous membrane of the mouth and leaves a rather cleansing taste which all observers comment upon. Whites drink it freely without apparent effect."

Later in the evening the men sang for us, still seated cross-legged back of the kava bowl; they sang well, in excellent time and melody, the bass voices booming out with fine effect and the tenor being rendered in a falsetto voice. Most of the songs were in Fijian, but some were renditions of English songs; among the latter was "Tipperary" and others brought back from the great war. Like almost all native peoples the Fijians enjoy singing, but on this occasion there was no musical instrument. It seemed to me that the men showed considerable training as the parts were very well carried.

After an hour or so of this, the other guests left; Mr. Welch and I remained, and, by request, spent some time in telling the men about Iowa and the wonders of the United States in general, such as the size of the country, its railroads, skyscrapers, the University, etc. The men listened in silence, most of them with heads bowed, very intent on hearing and understanding everything that was said, as Ratu Popé patiently translated our remarks. He was the only one at Bau, so far as we discovered, who understood English. The only sound from the men was a peculiar sucking

[1] Fiji, its Problems and Resources, p. 99.

in of air between the upper teeth and tongue, their expression of astonishment. I asked Ratu Popé if the men believed the stories of seemingly miraculous things that we told, and he said, "Every word of it, and they will stay up all night to talk it over." It is really quite a novel sensation to address an audience in full confidence that one will be implicitly believed, a sensation not common among speakers in the United States.

The chief invited Mr. Welch and me to sleep at his home and we retired at a late hour, nearly midnight in fact. We had cots with a covering of fine matting and a light blanket. When we had retired, the chief left, bidding me "sleep the sleep of the just," another unusual experience. We were then the only occupants of the house. A soft breeze came through the windows and there were no mosquitoes. An almost absolute quiet prevailed, so we had a very refreshing sleep.

We were awakened early in the morning by the beating of the native drum or "lali," about the only musical instrument we saw in Fiji; it is simply a hollowed out log, which gives off a loud resonant note when struck with a club. We afterward found that it was used to call the congregation to church in the evening. Mrs. Welch came from the women's house to join us at breakfast and Ratu Popé presided with fine courtesy. We had excellent fish and the chief claimed that the head was the choicest part. There was also very good coffee and the best bread-fruit I have ever tasted, raised on the island and baked in hot ashes. It was perfectly white, very light and mealy, resembling mashed potatoes, but drier and more flaky.

We then made a tour of the island under the guidance of our host, taking our cameras with us, although the day was overcast with alternating brief periods of sunshine and light showers. Wylie had my tripod, so time exposures were impossible; but the results were fairly good and the place the most interesting that I visited in Fiji. The little island is divided into three parts; the chief's compound with several houses for his immediate family and retainers; the native village on three sides of a park-like square, containing the cricket ground and some very large and handsome shade trees; and the missionaries' compound on an eminence beyond the church. This latter was a well built structure and we attended part of the service which was of the Wesleyan order. The people were dressed in their Sunday best and the singing was good; some of the songs were the same as are heard in church or Sunday School in the United States. It was evident, however, that not much attention was given to the real meaning of the songs, but this state of affairs is by no means confined to Fiji.

The missionary and his wife had a good house on the highest point of the island and seemed comfortably situated. The Rev. Mr. Adamson was a fine manly type of fellow. As it was Sunday, the question of photographing the people at their daily tasks proved a very delicate one. I said that I had come a very long distance to visit the place and had only one day to spend at Bau, the most historic spot in Fiji; but that I was unwilling to do anything against his wishes. He said that he was "no sabbatarian" but that they had taken great pains to induce the people to be very strict in their observance of the Sabbath. While he did not feel that he could give his specific consent, he would not oppose us in the matter, particularly if the chief desired the photographs to be made; and so the matter rested.

It would be impossible to find a greater contrast than the Bau of the present, in its quiet Sunday restfulness, with its earnest church services and orderly, neatly dressed people as we saw them that day, makes with the Bau of two generations ago. Then it was probably the bloodiest spot in all Fiji, perhaps in all of the South Seas, the seat of the Fiji kings and the home of the most war-like tribe. The men at that time were inveterate cannibals, parties from Bau going in the darkest night to the adjacent mainland for the purpose of clubbing a few unwary natives and returning with their "meat" for the subsequent horrible orgies of a cannibal feast. We were shown the stone against which it was the cheerful custom to dash out their victims' brains. This stone is now in the Methodist church and at one time its hollowed top was used as a baptismal font! Afterward, however, this use was abandoned as being too gruesome to be associated with that sacramental function. It seems that King Cakobau, the grandfather of our host, was finally persuaded to adopt Christianity and gave this stone to the church in testimony of his change of heart and his "putting away of old things."

The lives of the first missionaries at Bau were far from pleasant, and we were told that on some occasions, when the missionary himself left home on official tours, the natives would enliven the loneliness of his wife by hanging fresh strips of human flesh on the hedge in front of his house. This was to make things cheerful for her during her good man's absence.

We were shown the site of the old Devil House on a sort of artificial hill near the shore. This heathen temple was reached by flights of stone steps which are now in a state of almost complete ruin. Around the base of the mound were a number of stones, resembling gravestones, taken as trophies from other tribes; they appeared to be regarded somewhat as battle-flags are regarded by European nations. A number of these stones were still standing. The Devil House itself had been destroyed in a hurricane, but pictures of it are extant. It was much like other thatched houses but rather larger and better built. Here the rituals of cannibalistic feasts were enacted, for the custom of eating human flesh had its religious significance it seems. Only the chiefs were allowed to enter the sacred enclosure and the ceremonials are said to have been quite elaborate. The chief introduced me to a very old man, the oldest on the island, very tall and straight, with gray hair and beard. His face was a really dignified one and quite European in physiognomy. This man was a cannibal in his earlier days and seemed rather proud of the distinction. The old coronation stone was not far from the Devil House and looked like a simple stone post, about three feet high, planted in the ground. I understand that this is the equivalent in Fiji of the "Stone of Scone." The old cannibal said that he had been present at the coronation of Cakobau, the last of the Fijian kings, and stood in a position assumed by that potentate during the ceremony. With permission I took a photograph of both of these old relics of by-gone days as they stood together.

I also secured photographs of Ratu Popé, his house, the native village, the kava ceremony, fishermen and their nets, Ratu Popé's thirty-man canoe in course of construction, the Devil House, a group of girls under a huge banyan tree, one of women and children seated on the ground, fish pots, women weaving tapa, and the graveyard back of the church which contains the grave of Cakobau, and several members of his family.

The chief invited me to stay another day to see the fishermen at work, for the men of this village are the most noted and skillful fishermen in Fiji, being justly celebrated for their success with spear, nets, fish-traps, fish-pots, etc. But the wind seemed to be rising and it was doubtful if he could put me ashore on the main

The first kindergarten in Fiji (See page 98)
Baker Memorial Building, Wesleyan Mission (See page 98)
Fijian students at the Wesleyan Mission (See page 98)
(The middle and lower photos were presented by Rev. Dr. Le Lean of the Mission)

PLATE XVI

Ratu Popé, Chief of Bau, grandson of the last Fiji king (See page 91)
The kava ceremony at Bau (See page 92)
The "Coronation Stone" at Bau and an old Fijian who was once a cannibal (See page 96)

island if a storm should arise; moreover our time in Fiji was becoming too short for the things we wanted to do.

We had to be transported in boats to the launch, which on account of the low tide was anchored perhaps a half mile off the shore, so we bade goodbye to our courteous host and departed just in time to board the launch before a heavy rain squall struck us. The trip back to Suva was rather uneventful, although we were stuck in the mud several times; but this afforded us occasion to visit with the inhabitants of the various villages along the bank and to see more of the native customs than would otherwise have been possible. The channel through which we went served as a cut-off to the Rewa river; at low tide it is a very muddy and uninteresting stream but we were glad to see the little villages tucked away under the shade-trees along the shores. The architecture of the houses, however, is quite monotonous in their resemblance to hay-stacks. Of course, the villagers were interested in our unexpected visit and came to see the boat and the strangers, but our intercourse was greatly hampered by the inability of either party to understand the language of the other. One thing that struck me particularly was the cleanliness of the Fijians both as to their houses and persons. Although very bare and provided with simple earthen floors, the inside of every house I saw was neat and scrupulously clean; and clothing, although exceedingly abbreviated, seemed never to be soiled.

On our arrival at the Fiji Club we found that Mr. Fell, Wylie, Thomas and Glock had returned from their trip to the interior of Vitilevu. They reported a highly interesting experience and were enthusiastic about the grandeur of the scenery, declaring that some of it was comparable to that found in the Yosemite. Wylie was delighted with the beauty of the jungle, with its grand display of tree ferns and other tropical vegetation.

The next day Dr. and Mrs. Stoner started on a trip to Levuka and the day after, Thomas and Glock left early in the morning on a little steamer for the other side of Vitilevu where the climate was quite different and notably drier.

Suva is quite oriental in appearance. The streets are lined with little tailor shops, haberdasheries, Indian curio shops and some good shops, or stores as we would call them, owned largely by Englishmen, and carrying an extensive line of European manufactures. The people often walk in the middle of the street, turning to the left after the English fashion. There are many

Indians with various sorts of turbans, some of which look like bath-towels twisted around the head. The women have a furtive expression, wear rings in their noses, many bracelets and ankle rings but no shoes or stockings. They are usually dressed entirely in white and have finely chiseled features. Some of the men are quite handsome with black beards and imposing turbans, and have the dignified bearing that denotes the high caste Hindu. The whites dress in European fashion, of course, and are not overfond of the Indians, evidently viewing them as something of a menace because of their increasing in numbers and influence.

The Fijians never cover their heads, as their great mass of outstanding hair provides sufficient protection and an imposing headdress as well. Secretary Fell is evidently a sincere admirer of these natives and says that any stranger could go unprotected into the remotest parts of the interior and his life and property would be entirely safe.

I met Mr. Hoodless, Acting Superintendent of Schools, who invited me to accompany him on an inspection trip to the Methodist Mission, about twelve miles from Suva. This is the longest auto ride that it is possible to take from the capital of Fiji, although there are many autos there. The Mission is in charge of the Rev. Le Lean and his wife and embraces an extensive tract of high ground overlooking the Rewa river from an elevation sufficient to catch the cool sea-breeze at almost any time. There are about five hundred people, Fijians and Indians, living there, but the races are separated owing to their mutual dislike and even hostility. The main building is Baker Memorial Hall, made of cement blocks resembling cut stone and covered with tiles. In all there are about twenty buildings, many of them small cottages where the married students live. In Baker Memorial Hall (erected in honor of a Rev. Baker who was killed by the Fijians) is the main school where the missionaries are assisted by two young women from Australia and several Fijian men. Most of the students are being prepared for missionary work, and a finer looking set of young men would be hard to find anywhere. The Rev. Le Lean took me over a good deal of the extensive tract owned by the Mission and we also visited his home which seemed well built and comfortable, and commanded a beautiful view of the open country with the blue sea beyond. Here also is the first kindergarten established in Fiji where about twenty little Fijians looking astonishingly like the "pickaninnies" of our our southern states are presided over by a competent looking white woman assisted by one or two Fijian men. The children went through their various stunts for our benefit and with a good deal of enthusiasm. They looked well nourished and happy. We saw the gardens where a sufficient amount of taro, bananas, yams, tapioca, etc. is raised to supply the wants of the entire community of five hundred people. We had a fine lunch with Rev. Le Lean and his wife and enjoyed a rest on their veranda. It rained almost continuously in the afternoon, but we saw some of the work-shops where the natives are taught wood work and some metal work by a competent English mechanic; they make chairs, tables, bedsteads, etc. for the other missions, under Government contract. I was told that a superintendent of agriculture and stock-raising was coming from the Philippines and that American agricultural methods were to be introduced.

The Methodist and Catholic Missions, when up to a certain standard grade, are financially helped by the Colonial Government and seem to be doing a large part of the educational work in Fiji. The students are taught to contribute financial aid to the Mission whenever possible, and I was told that the Fiji men of the Mission, together with their native teachers, had recently been working on the Government roads for three weeks, earning two shillings a day, nearly all of which was turned over to help the cause of the missions. Whenever I hear returning travelers engage in the popular pastime of "knocking the missionaries" I think of the splendid work of Dr. and Mrs. Le Lean and enter a prompt, emphatic protest. Having read Mr. Frederick O'Brien's "White Shadows in the South Seas" together with his comments on the missionaries, I asked Mrs. Le Lean whether it was true that the natives had suffered severely on account of being compelled to wear clothing prescribed by the missionaries. She replied that they, the missionaries, had done nothing in the way of insisting upon clothing, except demanding that the most primitive demands of decency be observed and that the clothes they wore be entirely sanitary and sensible. And this appeared, from my observation, to be absolutely true.

Secretary Fell invited me to dine with him at the Grand Pacific Hotel, where both men and women appeared in formal evening dress. Somehow this does not accord with our preconceived ideas of Fiji, but it seems that the formal dress of the European has now encircled the globe and no place, however remote, is secure from its invasion. Mr. Fell told me that a white woman could go alone anywhere on the islands without fear of molestation from the Fijians.

Having decided to ship our Fijian collections home direct from Suva, instead of taking them with us to New Zealand, we spent the day of June 30 in arranging for their transportation on the Niagara due to call on July 1. As there was no American consular agent in Fiji we found it impossible to secure a bill of lading in proper form, a matter that caused us considerable trouble later on.

In talking with the various officials at the Club and at the hotel where we took our meals I gained considerable information about the Fijians who are sincerely admired by most of the Colonials. Although they have very evident negroid characteristics, they differ from Africans in length of hair, well formed noses, legs with fully developed calves and thighs, comparatively small feet (our reef man Alfred could wear Thomas' shoes which are of no more than average size for a white man) and in less protuberant lips. The Indians, having for many centuries been subjected to a severe struggle for existence in a densely populated country, are more ambitious and willing to work to accumulate property than the Fijians. The Fijians are looked down upon by the thrifty Indians but regard themselves as superior men at least physicially.

Hookworm and elephantiasis are prevalent in certain districts, the latter, according to my informant, being conveyed by the bite of a large mosquito. In speaking of the disease called elephantiasis, Mr. Fell said that the male glands were so enormously enlarged as to sometimes weigh as much as eighty pounds! Malaria is unknown or at least rare. The most prevalent disease is known as "yaws" and attacks the women in particular. It is allied to syphilis, but is not contracted venereally and hence is not regarded as a proof of immorality, although it manifests itself by much the same symptoms.

The Niagara came in on the first of July, according to schedule, and was full to the brim. Suva is very lively on "steamer day" and there is quite a market for souvenirs on the dock and street leading to it, where women display their wares in the shape of mats, tapa cloth, many kinds of beads and trinkets made of shells and coconut shells. I was interested in the corals displayed for sale and in the fact that many of them were dyed in fancy colors of pink, blue, green, etc. to make them more attractive to the tourists who came ashore for the few hours the steamer was in port. The Fijians are skillful in weaving and some of the mats, baskets and rugs, were attractive and sold quite readily. The women sat cross-legged along the road with their wares spread around them and seemed to greatly enjoy dickering with the passengers, although few of the native women knew more than a few words of English.

Thomas and Glock returned from their trip to the north side of Vitilevu and reported a very hard, uncomfortable experience. The small coastal steamers called ''around the island'' steamers are poorly equipped for passengers, with limited accommodations and scanty fare. Both of the men were about exhausted. Thomas, who seems able to stand almost anything, looked more tired and fagged out than I had ever seen him.

Wylie was to remain in Fiji some nine days longer than the rest of us to finish some work he had begun. He, too, had been overdoing in the matter of work and felt the strain. I urged him to take things easier for a while, but he was so enthusiastic about the opportunities offered that he was loth to slow up. My own work on Makuluva, although strenuous at times, was more healthful than work in the interior and I had thus far been in excellent health.

On Sunday, July 2nd, some of us went to the Fiji church (Methodist) and greatly enjoyed the service. It was ''Parade Day'' and the Defense Force turned out in a body; a fine soldierly set of men they were. The band was exceptionally good. Perhaps three hundred people were present in the church, nearly all Fijians, and the room was well filled with as earnest and attentive an audience as one would find anywhere. The white visitors sat on the platform behind the preacher. He, the Rev. MacDonald, an energetic white man of perhaps forty, preached a really able and eloquent sermon, although, we understood not a word of it. But his command of words was evidently effective and he never had to hesitate for proper expressions to use. His gestures were restrained, but eloquent, and the attention of his audience seemed literally breathless. These people, many of them natural orators, knew how to appreciate him as he discoursed on the text ''Lift up your eyes unto the hills.'' The congregational singing was really fine, the four parts being well sustained; the bass from the Defense Force was particularly effective.

After the service the Defense Force paraded, led by their band, and then proceeded back to their barracks. They are a well disciplined body of men and make a fine appearance, being well set up, with their imposing head-dress of bushy hair and khaki uniforms consisting of a military blouse, belt and the "sulu" for trousers. The Defense Force wore sulus which terminated below in a number of sharply pointed flaps and their legs and feet were bare.

A prominent member of the band was Savou, clerk to Secretary Fell, a fine looking, upstanding fellow with the handsomest head of hair I saw in Fiji and was exceedingly proud of it. He could speak English, and allowed me to photograph him in his uniform, the particular point of interest being his hair. He was quite willing to talk about it and I asked him to tell how the imposing result was achieved. He said that the main thing was to keep it clean and that he washed it thoroughly twice a day in warm weather and once in cold weather. It was then carefully dried, after which coconut oil was rubbed in thoroughly so as to reach the scalp. The real dandies, of which he was evidently a good specimen, never rested the head on the ground or a pillow when sleeping. Instead they used a section of round wood such as bamboo placing it beneath the neck instead of the head so that the precious head-dress could not be disarranged. Savou was one of the men who accompanied Secretary Fell and three of our party on the trip to the interior, and our men admired him greatly.

The Defense Force is regarded by the Colonial authorities as a valuable military body, excellent soldiers who take naturally to the life of the constabulary, are brave and obedient to orders. Fiji, by the way, furnished its full quota of men in the great war and is naturally proud of it. It seems to me that Great Britain's management of native troops is one of the real mainstays of her Colonial policy, and they have seldom proved unfaithful; so far as I have been able to ascertain they are uniformly loyal to their king.

Savou escorted Glock and me to the Fiji museum which is in the Botanical Gardens beyond the Grand Pacific Hotel and on the Victoria Parade. This Parade is a sort of boulevard well worth seeing, broad and well-paved leading along the shore from the main business section to and beyond the well kept, imposing Botanical Gardens which are themselves a credit to the metropolis of Fiji. In it is the present Government House which looks as though intended for an officer's barracks. The original Government House was destroyed by fire, and His Excellency, Governor Rodwell, occupies a part of the building in the Botanical Garden, awaiting the erection of a new official residence.

In the same grounds is a model Fijian house built by the natives to illustrate their style of architecture at its best. It is larger than any other native structure that I saw, with a steep roof and huge ridge-pole extending beyond each gable. Its roof and sides are neatly thatched as is the universal custom in Fiji, and the interior is occupied by an exhibit of various articles of native manufacture. It was not open to visitors on Sunday.

The Fiji museum is a two-story building, apparently of cement, with a large, double-decked veranda in front. Inside it is poorly lighted owing to the obstruction of light by the deep verandas. The collections relate mainly to ethnological matters, almost exclusively Polynesian. Naturally, Fijian material predominates, and much of it is of exceptional value, but it is poorly displayed, many of the cases having much more wood and less glass in their construction than is in accord with modern museum methods. The rooms are too dark and the material too crowded for effective display. There was considerable native pottery, models of houses and boats, masks, kava cups and bowls, tapa cloth and other samples of wearing material, baskets, whales' teeth, knives, spoons, breast plates, canoes and paddles. In one room was a great pile of unassorted war-clubs which would make an imposing display if properly arranged and exhibited.

The museum is in charge of an elderly curator who did not seem disposed to vary his collection by means of exchange, but he treated us with courtesy.

Returning to the Fiji Club we paid our bills and wrote notes to the members who had treated us with exceptional kindness. The club house had been a real haven of rest during our stay at Suva and served as our base of operations. The sleeping rooms were as comfortable as one could desire, and the service of the neatly uniformed, well-trained Indian boys exceptionally good. The house commanded a beautiful view of Suva Bay on one side and the city on the other. Being on high ground it was always cool at night and we had no trouble with mosquitoes, but the beds were all provided with nets, as is the rule in tropical countries.

As Suva is on the wet side of Vitilevu we expected to be considerably hampered in our work by rainy weather. But although the annual rainfall is sometimes as much as 172 inches, we saw little of it; however, it looked as if it rained in the interior nearly every day. When our men were on the trip with Mr. Fell we expected them to report drenching rains almost daily, but they said that they encountered very little, although dense fogs and mists often interfered with their view, especially from the mountain tops to which they occasionally climbed.

Mr. Wright, the Government Chemist, had been exceedingly helpful during our whole stay. He had given a convenient room in his laboratory to Professor Wylie where the precious botanical specimens could be handled and prevented from spoiling; had also aided Dr. Stoner very materially in his entomological work, and had given freely of his time and extensive knowledge to any of our party that could be helped thereby. He is a Cambridge graduate, a thoroughly competent scientist in his own specialty, and widely acquainted in other fields of knowledge.

On the morning of July 3rd we made farewell calls on our colonial friends and wrote notes to others expressing our appreciation of many courtesies. Colonial Secretary Fell had more than made good his promises of official and personal aid to the expedition. It was through him that we occupied the delightful little island of Makuluva, where we had unsurpassed facilities for working in comfort without being interrupted by the numerous visitors who often, although unwittingly, are a great hindrance to visiting strangers with a serious objective and limited time. Mr. Fell also made it possible for three of our party to take the journey with him into the interior of Vitilevu, a trip of surpassing interest and one that will be remembered with delight by those who were so fortunate as to be included.

There were several other men, mostly in the Colonial service, who greatly aided us, whose services will be noted in the chapters written by Professor Wylie, Professor Thomas, and Dr Stoner. One thing that I very much desired to take home with us was a Fiji flag, but I was unable to do so. It seems that these colonial flags are used only by colonial officials and in connection with governmental buildings. Private citizens are apparently not allowed to possess them nor are they for sale at the various shops. Hence we were compelled to depart without securing the official colonial flag of Fiji.

Our steamer, the Makura, came in at about ten o'clock in the morning of the third of July, but we did not go aboard until about the middle of the afternoon. As noted before, Wylie was to remain in Fiji until the next steamer called on its way to New Zealand; he felt that much remained for him to do and, moreover, had arranged for another trip into the interior with Mr. Wright. I certainly disliked leaving him there as he had worked too continuously and I was afraid of a breakdown. Besides, he was my "bunkie," a close associate during our outward voyage to Fiji, and later on Makuluva, and had shown me what a royal good fellow he was.

We found mail from home awaiting us on the ship and, although the news was about a month old, it was the latest we had and most welcome. It was necessary to see that all of the equipment and baggage was transferred from the dock to the ship, each parcel carefully checked off until the list was complete. Dr. Stoner could be depended upon to attend to that and to keep track of our goods and chattels at all times.

Mr. Fell came aboard to see us off, accompanied by Mr. Pilling who had so efficiently attended to us on our arrival. Their primary object, however, was to bid good-bye to Sir Charles Davison, Chief Justice of Fiji, who was leaving for Australia. Many people were on the dock to see the Makura off, most of them to bid farewell to the Chief Justice who seemed a very popular official. Our two Fijians were on hand and Alfred's honest face loomed up amid the crowd. Esile was there, too. Both had served us faithfully and had taken an extraordinary interest in collecting on the reefs and flats of Makuluva. Their keen eyes had seen many rare specimens that would otherwise have escaped us, and we think of them often when studying our collections in the laboratories at home.

Here we saw for the first time a leave-taking custom that was extremely attractive and characteristic, we believe, of the South Seas. One end of a long roll of brightly colored paper tape or ribbon is held by the departing friend on the steamer and the other end by a friend on the wharf. As the ship slowly leaves the dock scores of these ribbons stream from her decks and are unrolled slowly by those ashore, who sometimes fasten several together so as to prolong the "tie that binds." One by one the ribbons are broken or the ends are reached until only a few at the stern are intact and they soon follow suit. Finally the last one is broken and the connection between the friends on deck and those on shore is severed amid the waving hats and upturned faces.

This pretty custom and the Hawaiian fashion of bedecking departing friends with ''leis'' or wreaths of brightly colored flowers, are farewells that struck us as beautiful and expressive of the friendships that the traveler finds in the far away islands of Oceanica.

CHAPTER VI

THE FIJIANS[1]

The population of the Fiji group of some two hundred islands lying between 15° and 22° South latitude was, in 1921, 155,234, of which 89,562 were native Fijians, 61,150 Indians (that is natives of India), and 4,552 whites; or in the proportion of 58 Fijians, 40 Indians, and 2 whites per 100 persons. It will be seen, therefore, that there were nearly fifty "blacks" to every white person on the islands.

These latter, the Colonials, are the officials, planters, traders, and missionaries. The Indians are mostly small farmers, laborers, house servants, and small shop-keepers. Usually the Fijians live in small communistic villages and work only enough to supply their exceedingly simple needs. They are independent and seldom belong to the servant class. Occasionally they work "by the job" on the Government roads or as dock laborers on "steamer day."

The whites are, of course, the ruling class and are almost all British; most of the Indians were imported as laborers on the plantations, the Fijians being the only real natives. As such they interested us greatly. We found them extremely different from our preconceived notions gained from various publications of travelers from the South Seas. Indeed, our friends received the news of our departure for Fiji with cheerful predictions that we would be welcomed with gastronomic fervor, which may serve as an index to the ordinary notions Americans entertain regarding the Fijians,—that they are degraded savages and cannibals. This opinion is just about as up-to-date as a belief that the present Americans are given over to the practice of burning witches!

A hasty review of recent publications regarding the South Sea Islands gives the impression that most Europeans and Americans go there without any idea of learning things of ethical importance. Some go to exploit the natives commercially, some to teach them

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[1] The author is indebted for much of the information in this chapter to a work called "Fiji, its Problems and Resources" by Major W. A. Chapple, Whitcomb and Tombs, Limited, 1921; and also to the narrative of the Wilkes Expedition, Vol. 3 which gives an excellent account of the Fijian natives as they were in 1840.

to be good and to be civilized; still others to reap a rich literary harvest in expatiating on lovely women with scant raiment and still scantier morals.

We honestly liked the Fijians. They are physically a fine race, well built, muscular fellows, not flabby like many other Polynesians that we saw. They are upstanding and look the stranger in the eye without truculence on the one hand or servility on the other. They are wise in adhering to their native costume, the sulu, and wear neither hats, shoes nor stockings. They are considerably darker than most Polynesians we saw and exhibit a negroid strain, probably from an admixture in past times of blood from New Guinea or New Hebrides. As already mentioned, their chief ornament is their bushy head of hair that stands out four or five inches like a black or reddish-black halo and is really an imposing and dignified affair. I notice from the narrative of the Wilkes Expedition that in 1840 many of the Fijians were heavily bearded, but at present they are almost universally without beards.

It would be hard to find a greater or more rapid change for the better than has taken place in the Fijians during the last three generations. One has but to read the narrative of the famous Wilkes Expedition, which visited Fiji about 1840, to realize their condition at that time. Indeed the story is so revolting as to be almost incredible. Constant wars, pillage, cannibalism, massacres of whole villages, parents murdered by strangulation or being buried alive by their own children, wives burned alive at the funeral of husbands, the killing of maimed persons and eating the flesh, often putrid, of even their dearest friends. All these atrocities fill many pages in the narrative as it relates to the main island of Vitilevu, and these conditions remained up to the memory of men now living, one of whom I conversed with at Bau.

Compare this nightmare with the people as we found them—a people courteous, kind, honest and law-abiding; with no experience of tribal war for many years, a people among whom the stranger can travel in perfect security; a people uniformly hospitable, even in the remotest jungles of the interior. And this is true not only of chiefs like Ratu Popé but poor people in their most primitive villages.

No one can contrast this situation with that prevailing a couple of generations ago without seeking the cause of the remarkable transformation. In my opinion it is due almost entirely to the wise Colonial policy of Great Britain on the one hand and the work of the missionaries on the other. The Colonial Government interferes as little as possible with aboriginal customs and habits and controls their excesses with a kindly firmness. The Fijians are allowed to have a hand in local government and some of them hold offices of real power; Ratu Popé, for instance, being a member of the Executive Council of Fiji.

In reading the accounts of returning travelers one finds a pronounced tendency to criticize the missionaries. The Colonial authorities, who certainly know the situation, admire and coöperate with the various missions, be they Methodist, Roman Catholic or of any denomination that is earnestly seeking to help the natives. My own visit to the Wesleyan Mission, already described, convinced me that these influences are all for the good of the people among whom and for whom they work.

We found that life in Fiji was reduced to the simplest possible terms, in sharp contrast to the amazing complexity of our modern civilization. Here indeed is the real "simple life" in its nearly perfect expression. The Fijians are criticised because they are disinclined to work, or at least to work continuously. But why *should* they work? The expense of maintaining an ordinary Fijian family in the simple comfort to which it is accustomed is reduced almost to the vanishing point and the Fijian's family budget worries him but little. His bill for clothing is next to nothing, as his garment when at home and not expecting visitors, is the sulu, which answers every purpose of decency. Protection from heat or cold is not necessary in that climate. On Sunday the men in the more civilized parts of the islands put on a cheap cotton shirt and the women a sort of one-piece garment much like what we used to call a "mother hubbard" reaching from neck to ankles and without frills or furbelows of any kind. Indeed its disadvantage is its homeliness. I heard no mention of underwear for either men or women, and doubt if it exists in Fiji. So the tailor's, shoemaker's, milliner's and dress maker's bills are of insignificant proportions.

The family residence involves almost no expenditure at all. The Fijian cuts the poles for the frame from the trees standing in the adjacent forest. The reeds used for the inside of the walls are from the same place, as is the sennit with which he binds them together. The roof is of thatch and the outside walls are covered with imbricating leaves. There are no partitions in the one-room house, the floor is of hard packed earth raised a couple of feet above the ground, and the women make the matting which serves for carpet. No glass, no hardware of any sort is needed. Above all he has no labor unions to deal with, neither is there any walking delegate to delay the work or pile on additional costs.

The furniture need concern him little. With a few shillings he purchases a porcelain plate, like a deep soup-plate about two feet across, in which the family meal is served, having been cooked outside on a sort of picnic fire used by several families in common. There are no beds nor bed clothes, except the fine tapa made by the women; no chairs, for all sit cross-legged on the floor; no plates, saucers, knives, forks, or spoons. Cups are made of halves of coconut shells and bowls are made of calabashes or gourds. There are no carpets, wall paper nor stoves, and very little kitchen ware. In fact his home is made merely to sleep in, for he and his family live out-of-doors, unless it rains, when they seek shelter until the shower passes. No stoves, fireplaces, nor furnaces are needed for heating purposes; therefore, there is no coal to shovel or pay for, no bill for gas, electric lights, water or telephone.

The women have no beds to make, dishes to wash, carpets to sweep or tables to set and their lives are devoid of the daily grind of endless nerve-wearing drudgery in the lives of the women of the middle and lower classes in America.

For food, a few pennies per week will supply the luxuries not produced in the community garden patch where they cultivate taro, yams, plantain and other vegetables; bread-fruit, mangos, coconuts, and pineapples are raised sufficient for their needs.

Fijians eat very little meat but are very fond of it. There is usually a pig or two, sometimes a goat and almost always a few chickens around the native house. I suppose they never have sufficient meat to satisfy their craving and this may have something to do with the cannibalism so universal in the South Seas in early days. It was taking advantage of about the only reliable source and really satisfactory supply of meat!

Fish are plentiful and good and the people living along the coast or the large streams can easily catch enough to supply their needs. From the size and number of weirs, nets, fish-traps, fish-pots, etc., that we saw near the mouth of the Rewa I should judge that fishing is one of their important industries and the source of much really excellent food.

These people of the simple life appear to be well nourished and content, often happy. Theirs is an out-of-doors existence and they have enough work to keep them in fair physical condition. As said before, they do not have the soft, over-fed, flabby bodies that one so often sees in Rarotonga and Tahiti. Their pleasures are simple but apparently adequate. They enjoy singing and often have good voices. Occasionally they indulge in a dance, or "meke," but we did not see men and women dancing together. Kava drinking is a sort of social ceremony, even more so than the "afternoon tea" of our British friends; but the women are seldom allowed to indulge as it is supposed to induce sterility, which may be at the foundation of the "tabu."

The women are modest and retiring in demeanor; they exhibit little sex consciousness, at least to the stranger, and in this differ from many of the inhabitants of other island groups in the Pacific. We saw no evidence of moral laxity and were told by the officials that the Fijians are a really moral people; neither was there evidence of any serious degree of admixture of races. The Fijians have a deep aversion to the Indians and want little to do with them, while the whites are not particularly attracted to the native women.

In regard to natural intellectual endowment, we find the Fijians by no means an inferior people. Ratu Sukuna, the Oxford man who visited us at Makuluva, was apparently up to the high mental level of the typical Oxonian and Ratu Popé had the mental grasp of affairs of the ordinary white official. Both of these men spoke English with as fine diction as our ordinary college man. As a matter of fact I am inclined to believe that racial differences in intellectual capacity have been greatly over-emphasized and that innate capacity has been generally confused with the effect of environment in our estimate of the comparative psychology of races. Of course it may be argued that the two chiefs mentioned are exceptional men; nevertheless they show a capability of intellectual achievement that would do credit to exceptional men of the so-called highly civilized races anywhere. Given equality of education, I believe the Fijians would show themselves by no means inferior to the ordinary Europeans in mental status.

After reading the romantic narratives of travelers who have visited the South Seas in recent years one has the impression that morality, particularly in matters of sex, is at an exceedingly low level among the peoples of Oceanica. Indeed, according to these returned travelers, they are not so immoral as unmoral. But we have positive evidence to the contrary in the little book, "Fiji, its

Problems and Resources, by Major W. A. Chapple," the most recent and authoritative publication I have found, and I am glad to quote from it. Speaking of the Fijians, he says, "Nothing is ever seen to offend the eye of the most sensitive observer. There are not even overtures of affection between the sexes. The women are shy and diffident. The men never leer or follow. The Fijian people might be all of one sex for all that in public is betrayed to the contrary. Hyde Park and Brighton Beach would shock them to stupefaction."

"The promiscuous love scenes portrayed in the pictures show the whites in an unfavorable light to the astonished Indians and Fijians, and if some precocious Fijian or agitating coolie on a visit to Britain were to undertake a 'Report' on the morals of the whites, it might be as lurid as other ventures of a like nature."

All this is so contrary to the stories brought back from the South Pacific by some of our popular writers that it is calculated to upset our preconceived notions regarding morality in the sunny isles of the sea. The writer does not challenge the veracity of these travelers, but does insist that their description does not apply to the Fijians. In this connection I was much interested in certain passages found in "Last Days in New Guinea," by Captain Monkton, who describes the Binandere, one of the largest tribes, as a people who "though fierce warlike cannibals were also honest, truthful, and moral to the last degree." It is interesting to note that it is very generally thought that the Fijians are derived in part from these people, and that some of their most commendable moral standards may have come down from a remote ancestry in New Guinea. It also reveals the curious fact that cannibalism may not be incompatible with good morals in other directions.

Taking it all in all every one of our little party considers the Fijians the finest race of natives that he has seen, and some of us have had a rather extensive acquaintance with native peoples. It is quite evident, moreover, that the colonial officials have a real admiration for the Fijians with whom they, of course, have had long and intimate contact. And I have heard warmer commendation for the Fijians than for any other native people in the colonial possessions of Great Britain which I have visited.

Nearly all of the Fijians live in small hamlets and villages which are, in fact, communes. A study of these miniature communes is well worth while as here we have communism reduced to its simplest form. The biologist studies the amœba as illustrating the

PLATE XVII

Fijian fishermen and their home at Bau They are showing their net (See page 96)
Fijian women and children of Bau (See page 96)

PLATE XVIII

Fijian women, the one at left wearing a fine tapa skirt (Photo by Glock)
Glock and Fiji guide, Savou Note characteristic hair of Savou (See page 102) (Photo by Thomas)
Typical Fiji village in interior of Vitilevu (See page 113) (Photo by Thomas)

simplest form of animal life, the single cell, and from this he acquires knowledge of the fundamental activities of protoplasm. In the same way we can investigate the communal villages of Fiji, devoid of the complexity of more highly advanced civilization, and thus get a notion of the primary activities of humanity as expressed in communism, as well as a conception of the natural results of the system.

Major Chappel says, "There is no ownership in Fiji, no individual ownership. All things are held in common, except the women—they are particular about that. If a thing is indivisible, it is in possession for the time being of the one who casually remarks, 'that's a nice hatchet or, 'that's nice yangona.'' I have an idea, however, that if an object comes into the possession of one in this way that another could relieve him of it by the same procedure, and that there is a sort of unwritten law by which the possession of a desired thing can be made relatively permanent by common consent, although the tenure is insecure if an individual chooses to invoke the communal law. A chief, however, can apparently secure permanent possession, on the theory that he is superior to the law.

The result of all this is a lack of incentive to the acquisition of personal property. The Fijian is apt to answer any suggestion that he accumulate property, with the remarks, "What's the use? It wouldn't be mine if I did get it." I imagine that this is the real cause for the reputation for laziness which they have among the whites. In the rural communistic villages the old traditions hold and there is no incentive to labor beyond the simple activities of their daily life. This is, I believe, the fatal objection to all real communism the world over. It offers no incentive, no motive for thrift, no urge to work steadily or more effiiciently or to embark in any enterprise that would result in added comfort or in bettering one's condition above the average of his fellows. The biologist believes that every advance in organic life is the result of the struggle for existence, or competition, which I believe is a better term; there can be no progress without that.

But there is another and more serious aspect of the case of the Fijian. The Indians, or Hindus, as we would say, were imported as plantation laborers or servants under the operation of the indenture system or the "cadet" system as it is called there. The men thus secured were usually of low caste, below par as it were. The system itself was iniquitous and led to much injustice and even practical slavery. Later the system was abandoned and the Indians allowed to shift largely for themselves. Coming from a densely populated country and an ancient civilization they had been subject for many centuries to an unusually severe struggle for existence. This struggle resulted in the survival of those who were most alert, best able to care for themselves, keenest in business dealing or in petty bartering. They were also marvelously frugal in their manner of life and used to enduring privation in order to accumulate a little property and get on in the world. Like the Hebrews, they were accustomed to the uses of adversity and eager to earn a wage that would enable them eventually to better their conditions. In Fiji they found themselves free from the galling bonds of the indenture system, in a land where a little work would satisfy their very modest daily needs and with almost no native competition to meet. The communistic Fijians were pitifully equipped to compete with these thrifty strangers from a foreign land. Accumulation of property was an idea utterly foreign to their traditions and way of thinking. In short, I believe that the fine, manly Fijians are no match for the Indian with his uncanny ability in driving a shrewd bargain, backed by many centuries of racial experience. The Fijian is but a child in an Indian's hands and can not cope with him in business matters. Thus there is a strong probability that the Fijian, like his brother of Hawaii, will be crowded to the wall by the steady encroachment of the newcomers until he loses out in the economic competition. Of course it might be possible for the Colonial Government to offset his handicap by legal restrictions on the aggressive tactics of the Indian, but it is hard to say how this can be effected.

Just as in Hawaii, the situation regarding the native birds is parallel to that of the native peoples. For in Fiji, too, the English sparrow from the East and the mynah bird from the West are successfully competing with the aboriginal avifauna. Here, too, the British Colonials on the one hand and the Indians on the other furnish the upper and nether mill-stones between which the unfortunate Fijians are threatened with racial extinction, and the struggle for existence seems likely to end inexorably in the survival of those best fitted through centuries of keen competition to survive. One can not avoid raising the question—Is the "fittest" actually the best race? In other words, is the Indian actually better than the Fijian?

If a fine, manly physique and independent bearing which indicates an adherent self-respect, a moral character that is fundamentally honest, a sex morality that seems to have definitely impressed the Colonial authorities, and intellectual capabilities that are demonstrated wherever adequate education is available are indications of superiority, then it seems to me that by these criteria the Fijians are a definitely superior race.

To arrive at any just conclusion it is always necessary to ascertain the point of view of the people against whom charges are made and judge in the light of the traditions and environment of the accused. Let us look at the most conspicuous charge, that of cannibalism, from their standpoint, confessing at once that no defense can be set up from the point of view of modern civilization. The natives of all islands in that vast stretch of ocean known as Oceanica were confronted with a great scarcity of a natural food:—meat. While we do not know definitely the origin of cannibalism, the most common explanation is, it seems to me, that this almost total lack of an adequate meat supply furnished the original incentive.

Aside from the sentiment that appears to be instinctive, practically among all races of mankind, there appears to be no *a priori* reason why human flesh is not available food, and many members of many races have, when under stress of hunger, availed themselves of this means of sustaining life. We know that this very thing has happened time and time again in the case of shipwrecked sailors, Arctic explorers, beleaguered cities and severe famine in many parts of the world. In the case of the Polynesians every battle resulted in the possession of the bodies of the slain foes. Would it be strange if some men under stress of hunger were tempted to avail themselves of this means of satisfying their native craving for meat? Upon experimenting, human flesh was proved to be not only edible, but life sustaining and satisfying. There was doubtless the further incentive, always a powerful one in the case of primitive man, of doing that which tends to terrify the enemy, fear being universally regarded as a powerful aid in battle. One of the commonest boasts or threats among savages is, "I will eat you after the battle!" Another wide-spread belief among these people is the idea that the victor attains the qualities of strength and valor that characterized the champion whom he has slain, and by eating his flesh can make them his own to aid in securing further victories.

By some such means cannibalism may have gradually become a recognized custom among the savages of Polynesia and in the course of ages have been firmly established by tradition and continued usage. It seems to have prevailed among all the islands about which I have been able to procure information. In New Zealand it was apparently almost universal, and, according to the universal testimony of the white contemporaries, these Maoris were certainly an exceptionally fine race of men. It appears, moreover, that this custom, atrocious as it seems to us, was often accompanied by conspicuous virtues and strict morality. In this connection the reader may be interested in rereading the testimony of Captain Monkton, given on a preceding page, in regard to the morality of the cannibal tribes of New Guinea.

Now that which has once been thoroughly established by custom and tradition is regarded as right by an overwhelming majority of any people or tribe. Conscience commends those who do that particular thing and condemns those who do not. Under these circumstances can we say that cannibalism was wrong from the standpoint of the old Fijians? Of course we regard it as atrociously wrong and criminal, but did the Fijian or his fellows consider it wicked to indulge in "long pig?" And if the answer is in the negative was the practice immoral?

In connection with Baker Memorial Hall already referred to, another instance suggests itself of the necessity of realizing the viewpoint of native people before passing judgment on their actions, however revolting they may be in the estimation of civilized men. This building was erected in honor of a missionary, the Rev. Baker, who was murdered seemingly without any provocation at all. After leaving Fiji I was told what is claimed to be the true story of this atrocity and was given the viewpoint of the natives. The story may be garbled or absolutely false, so far as I know, but it points a moral just the same.

It seems that a Fiji chief, accompanied by some of his followers, visited the missionary and seeing a comb which took his fancy, lifted it from the table and stuck it into his own bushy mop of hair. The Rev. Baker, perhaps without due consideration, reached out his hand and removed the comb from the head of his visitor and was at once killed by the other Fijians; a most cruel and unprovoked murder, according to our ideas.

But let us look at it from the standpoint of the Fijians themselves. According to their traditions or laws, if you please, the chief had a perfect right to appropriate to his own use anything

Group of Fijians in interior of Vitilevu
Native house at Viria (See page 124)
Fijian football team (See page 128) (Photos by Stoner)

PLATE XX

Boys in breadfruit tree A proud father
Fiji village, interior of Vitilevu (Photos by Thomas)

which he found in the territory over which he ruled. But a far more serious matter was the fact that, again, according to well established laws or traditions, the person of a chief and most of all his *head* is tabu, and to break this tabu by profanely laying a hand on the royal head was profanation, an unspeakably horrible act, the punishment for which was death! In other words the Fijians thought the killing of the missionary not a murder at all, but an entirely legal and justifiable execution! An understanding of the native point of view would have prevented the fatal error which lead to the death of a brave and devoted missionary.

In the narrative of the Wilkes Expedition the most revolting descriptions are given of the murder of Fiji parents by their own children. But according to the narrative even this horrid custom had its justification in the eyes of the natives. It appears that the old Fijians believed in a literal physical immortality, and that a man lived throughout the future life in the same condition as was his at death. For instance, if he had lost a leg, he was a one-legged creature throughout eternity. If he died old, decrepit and helpless, he was doomed to a future of decrepitude and helplessness. Hence these people feared a helpless old age much more than they feared death; and begged, even commanded, their children to make this horrible fate impossible by putting the parents out of the way before old age could overtake them. And so it appears from their point of view that the killing of parents was not an inhuman murder, but the carrying out of a sacred filial duty which traditions inexorably demanded.

I trust that no one will think for a moment that the writer is actually claiming that cannibalism, murder and patricide are commendable or right; but he is trying to show that these people should be judged in the light of their own traditions and usages, their own laws, and that these acts did not result in a feeling of guilt and moral turpitude which our standards involve; that they probably felt no remorse or severe condemnation after commiting such atrocities.

Before leaving this account of Fiji customs it might be of interest to state that I was informed on good authority that the old Fijians practiced the rite of circumcision and that it is still in practice to a considerable extent; but I learned nothing regarding its origin.

As to the whites, or colonials, of Fiji, our contact was limited almost exclusively to the official class. These are of course practically all British and much like those found wherever the British flag waves. They struck us as men who knew their business, or profession and understood how to deal with visiting strangers. It may be that, representing as we did a friendly nation and an American University, they were inclined to favor us more than they would unofficial visitors. But they did seem to fully appreciate our scientific objectives and doubtless were entirely aware of the possible publicity value of our visit to Fiji. However this may be, the colonial officials left nothing undone to further our plans and insure the success of our visit. Of course I was better acquainted with Colonial Secretary Fell than with any of the others. It was perfectly evident that he had a sincere admiration for the Fijians and he repeatedly expressed himself as being extremely fond of them. This attitude I have found to be quite common in all the colonial dependencies of Great Britain which I have visited. Officials do try to get the point of view of the natives over whom they rule with a sort of paternalistic despotism that may be mistaken at times, but is sincere and honest in the main; and very generally benevolent and well-meaning in spite of the unrest which seems so prevalent in the world to-day.

Of course colonial administration is often confronted with problems that are perplexing in the extreme. In Fiji the labor question seems to have been the hardest one to solve.[2] The responsibility of introducing Indian laborers lies mainly with the sugar planters, who represent by far the most important industry in Fiji. The planters were confronted by the fact that the Fijian natives would not work with any degree of constancy. European labor was out of the question as the cost was prohibitive on the one hand, and white laborers are ill-fitted to withstand the climate. Hence it was perfectly natural for the planters to turn to the millions of Indians for an adequate and constant supply of manpower without which their plantations would inevitably have failed.

Under these conditions it was natural to resort to the indenture or "recruiting system." This was completely under government control, the official agents in India procuring the recruits and sending them on, after careful investigation, to Fiji at the sole expense of the employing companies, who provided food, clothing and transportation. Under the terms of the contract the Indians were

[2] The information embodied in this discussion is taken almost exclusively from the work already referred to, "Fiji, its Problems and Resources," by Major W. A. Chappel, 1921.

required to work for their employers for five years, after which they could do as they pleased, theoretically. After another five years they had free passage back to their homes in India. Various laws were enacted to protect these indentured laborers; for example, members of families could not be separated and living conditions of the vessels on which they traveled were carefully checked up.

On the other hand, the indentured men could not abandon their work without being subjected to arrest and return to their employers. Since 1919, however, this feature has been abandoned at the suggestion of the employers. Major Chappel points out the fact that the Indians thus "recruited" were necessarily from the lowest class, those unable to make good in their own country and thus apt to be a troublesome element wherever they went. In the case of those who came to Fiji, there were an unusual number of women, the proportion in 1917, 22,600 women and girls out of a total of 61,150, made it possible for these people to lead, in general, a normal family life. Gradually the more ambitious Indians left the work on the plantations and took to other pursuits, such as shop-keeping, gardening, stock-raising and farming. Many became domestic servants in Suva, and I noticed that they were often employed as chauffeurs. It seems that the indenture system was abandoned in 1920 at the instance of the Indian Government.

The Indians increased in numbers with great rapidity from 1905 to 1917, the figures being 25,955 in 1905 and 61,150 in 1917, thus considerably more than doubling in a period of twelve years. Part of the increase was due to immigration and part to a natural increase due to favorable conditions. There is no doubt that the Indian is thriving in Fiji, is gradually acquiring property and political power. He is far more enterprising and thrifty than the natives whom he is supplanting, and in the natural course of events the Fijians will be eliminated not by assimilation, for the races do not mix, but by extinction. Major Chappel tells us that while the Indians more than doubled in twelve years, the Fijians have actually decreased. Measles and influenza caused a mortality of 50,000! Figures are not given showing the mortality among the Indians from these causes, but the net result was a doubling of the Indian population and an actual reduction of the native Fijian race—a result greatly to be deplored from a biological stand-point, for the Fijians are an unusually fine people. But, as Frederick O'Brien tells us in his "White Shadows in the South

Seas,'' this same thing is happening everywhere in Polynesia, and it seems evident that throughout that vast area the native races are doomed to extinction, although O'Brien seems to think the white man the guilty party. In Fiji, however, it seems to me that the Indians will be the cause of the obliteration of the native race. I believe, moreover, that the Colonial Government is anxious to save the Fijians from this impending fate but that it will find the task a difficult if not an impossible one.

So far as we could discover there were no Americans in Fiji except a dentist in Suva, nor was there an American consular officer of any kind, a fact that eventually made trouble for us.

CHAPTER VII

ORNITHOLOGICAL AND ENTOMOLOGICAL EXPERIENCES IN FIJI

By Dayton Stoner

In a recently published article wherein Doctor Frank M. Chapman, Curator of the Department of Birds, American Museum of Natural History, New York City, discusses the aims and objects of that institution, he says: "It is, therefore, the policy of the Museum to give its Curators wide field experience, knowing well that this will result not only in better collections but in more discriminating reports upon them."[1]

A somewhat analogous situation prevails at our own University in the department of zoology as well as in our other departments of natural science. Encouragement and permission are given their members to see, collect and study material in the field, both at home and abroad, and to participate in trips and expeditions which are organized with these objects in view in order that those thus engaged may better serve, and that, in turn, others may benefit through the agency of this participation. Such a policy had its inception at the University years ago and our recent efforts in the South Seas afford a good example of the favor in which such enterprises are still held by the university administration.

Since my own endeavors on the Fiji-New Zealand Expedition were almost wholly ornithological and entomological, I shall confine my remarks largely to these fields of natural science, realizing only too well, that a short stay of four weeks in Fiji (June 5 to July 3) and one of five weeks in New Zealand (July 7 to August 15) scarcely qualifies one to speak authoritatively on these subjects. However, one may, even in that short time, acquire at least some notion of the bird and insect faunas of the regions under consideration and this I shall attempt to set forth in the following pages. Mrs. Stoner accompanied me on many field excursions and assisted in the collecting, sorting and packing of material.

The opportunities for observing and collecting more and un-

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[1] Natural History, XXII, No. 4,311, (July - August), 1922.

usual forms of life were greater on this trip than on any that I had previously taken. Indeed, the South Pacific is particularly rich in peculiar and aberrant types of animal life. From the standpoint of animal distribution also, this trip was of special interest since representatives of both the Polynesian and New Zealand regions were encountered and comparisons between the two faunas could be made at first hand.

On the evening after our arrival in Suva a visit was paid us at our hotel by Dr. C. Harold Wright, Government Pharmacist and Acting Commissioner of Agriculture for the Fiji Islands, who, from the first, exhibited a keen interest in our work and extended many courtesies to all of our party in facilitating the objects of our visit. Among other things, Dr. Wright offered storage space in the Chemical Laboratory for some of our boxes and impedimenta. To myself, as entomologist, he issued a commodious working space in the office of Mr. H. W. Simmonds, Acting Entomologist for the Fijis, who was temporarily absent and did not return until several days after our arrival. This office occupied one wing of the Government Buildings and on being furnished with a key to it, a very marked concession, I was left to come and go as I chose.

It was in this room that I, on a subsequent occasion, indulged in my first—and only—drink of yangona or kava, the native beverage. Each day about ten o'clock it was the custom for one of the native Fijians in the Commissioner's office to prepare some of the dried root of the kava plant (*Piper* sp.) in a large wooden bowl. When this was mixed with water a yellowish-white fluid resulted which was passed around by the native in a coconut shell. The drink has an insipid taste but is exceedingly thirst-quenching. If indulged in too freely it is said to produce temporary paralysis of the lower limbs although it does not befog the brain.

From time to time Dr. Wright offered suggestions as to collecting grounds, aided in the identification of certain plants upon which I found insects and furnished literature on various groups of animals.

To Mr. Simmonds I am much indebted for information concerning collecting places, notes on the fauna of Fiji, the identification of specimens and for pleasant companionship in laboratory and field.

After spending two days at the Grand Pacific Hotel with its numerous Hindu servants in native costume, and said to be the finest hostelry in the South Pacific, the various members of our party followed their own inclinations very largely. Mrs. Stoner and I took up our abode at the home of Miss Rennie, where we were in a position to see and to participate in the home life of a European on a tropical oceanic island.

The spacious front garden with many tropical trees, flowers and bushes surrounded by a white picket fence, the house, a red-roofed two-story affair with the outside stairway almost over the front door, a back yard with orange, lemon, guava and banana trees, the small cement veranda, the long dining hall with its bare floor, chickens, shavings and other miscellany, our broken lamp set in a porcelain "jug," the "shower-bawth," to reach which one must cross the dining room, the ancient and obeisant native servant, Daniella, and the half-caste Annie—all made an ineffacable imprint on our memories. This was "home" while we were in Fiji and from this as a base we worked over various parts of the island.

Frequent collecting trips were made into the outlying districts where various types of habitats were visited. In the vicinity of Walu Bay, about two miles from Suva, the mud flats where we found tiger beetles (*Cicindela vitiensis*) were investigated; nearby bush and cultivated plots yielded a host of other insects. Everywhere, the thorny mimosa, or sensitive plant, with its pink blossoms abounded and the great expanses of it reminded me of our own red clover fields. As one walks over it the leaves fold to one side of the stem thus exposing the thorns upon which I frequently caught the bag of my insect net. Few insects are harbored by this plant.

The rice flats east of Suva were inspected and some of the arthropod inhabitants were taken. Scorpions and centipedes flourish in such places. The woods and bamboo thickets northeast of Suva furnish quite a variety of insects. A trip to Navua eighteen miles away was fairly productive of results, entomologically speaking; and two visits to the Tamavua quarry where material for road-building was being taken out and where some very fine native bush is to be found, yielded good results. Never have I seen such a tangled jungle as the vine-covered trees and earth here presented. All along the trail in the bush proper, *Clidemia hirta* with its blue-black fruit and few insect inhabitants, occurred in profusion. In the more open places the "mile-a-minute" (*Mecania scandens*) grew luxuriantly and attracted a more varied and abundant insect fauna.

On our journeys about Vitilevû our collecting efforts excited little curiosity or comment among the natives; apparently they either did not notice us or if they were interested their interest was not made known. Never were we followed about in the field and at no time did any one thrust his efforts upon us unsolicited, as so often happened among the West Indian negroes.

The little coral islands of Makuluva and Nukulau some twelve miles northeast of Suva proved to be good collecting grounds. On both these islands are Government quarantine stations which were under the immediate supervision of a care-taker in the person of a "hard-boiled" Australian, Mr. J. W. Sadler, who lived on Nukulau with a black woman, a parrot, three dogs and a multitude of chickens, ducks and flying foxes. We spent five days on Makuluva in collecting birds, insects and marine invertebrates. Nukulau is densely wooded and the "Sone," a creeping vine grows everywhere. Another vine which clings to the trunks and limbs of the trees is the "Dire Samu." It bears poisonous red and black seeds something like the "crab-eyes" of Florida and the West Indies. I found mosquitoes on this little island more abundant and troublesome than at any other place in Fiji.

One of the most interesting of the collecting trips which Mrs. Stoner and I made in Fiji included a visit to the native village of Viria some twenty miles up the Rewa river and about thirty-five miles from Suva. In company with Mr. and Mrs. Ashbel Welch of Philadelphia, Pennsylvania, and Lui, a native "boy" from the steamship company's office to act as interpreter, we left our lodging in Suva at noon of June 14. We traveled by motor car over ten of the comparatively few miles of surfaced road on the island to Dabui Levu, crossed the Rewa river by means of a cable ferry and arrived at Nausori a little later. The hilly and winding road, lined everywhere with the ever-present mimosa and lantana, had taken us over a very rough but beautiful part of the island. We passed in turn small cleared areas, dense bush with magnificent tree ferns, now and again a native house or small village with its adjacent taro patches, and a large tapioca plantation. Occasionally we met a blasé Fijian or a garrulous Hindu who passed the usual greeting, "Salaam, sahib."

At Nausori, after a brief wait which time I occupied by collecting water-striders in a small creek near by, we boarded the de-

Offices of Colonial Department of Agriculture (See page 122)
At left—Mr. C. Harold Wright, Acting Director of Agriculture (See page 122)
At right—Mr. H. W. Simmonds, Acting Entomologist (See page 122)
(Photos by Stoner)

PLATE XXII

Quarters of our entomologist at Suva (See page 123)
Native bush at Tamavua (See page 141)
Villagers at Viria (See page 128) (Photos by Stoner)

crepit and leaky gasoline launch "Tomy," which was to be our means of conveyance up the muddy Rewa for the following five hours.

The place of honor, the small cabin in the prow of the boat, was turned over to our party while the other passengers, mostly Hindus, occupied the remaining available space in the larger cabin toward the stern. Mail and baggage were stored on the upper deck and in various out-of-the-way places.

Apparently considerable speculation was rife among the Hindus and Fijians on board as to our nationality, destination and business. After much talking, laughing and gesticulating among themselves they finally struck up conversation with Lui who, upon being pressed for an answer as to our identity said in Fijian, "O, Americans! all big chiefs." The matter having been thus amicably and satisfactorily settled, the passengers occupied themselves by reading, writing, talking and smoking. Some were very adept at rolling long, black and exceedingly formidable looking cigars; however, cigarettes were the favorite smoke and the Hindus had a peculiar method of holding them between the thumb and base of the forefinger with the lighted end enclosed within the palm of the hand. Some "smokes" were made to serve two or three persons.

As the "Tomy" coughed and chugged slowly up stream frequent bailing was necessary and stops were made here and there to take on or discharge passengers who sometimes found it necessary to wade ashore from the boat; considerable areas along the banks were thickly covered with coarse para grass; at frequent intervals along both sides of the stream were large cane fields; in some places the uncut bush extended to the river banks. A few native houses and small villages were passed; and, at one of these, Naduruloulou by name, where the boat stopped to discharge mail, the Magistrate's Court was in session.

As the journey progressed the river became shallower and narrower and the captain was obliged to zig-zag back and forth in order not to go aground. In spite of his care we scraped bottom several times. Once the engine stopped; the gasoline tank was empty; the precious fluid must be conserved as much as possible in Fiji for there it costs three shillings sixpence (about 75 cents) a gallon; from one of the tins on deck the tank was filled and we were again under way.

Darkness began to come on—it comes very quickly in the tropics; a single smoky lantern served to light the way only dimly but still we chugged on although the crew of three now bestirred themselves and it was evident that a landing was soon to be made. After a little the captain ordered the mate to call to some one on shore for a lantern and after much halloing and talking a number of lights appeared among the trees along the high bank and soon the boat came to a stop at a shaky wharf.

It was a queer feeling that came over us as we were escorted through the darkness up the steep, slippery bank by a group of babbling natives who could speak and understand only a limited amount of English. We began to wonder if, contrary to what we had been led to believe, cannibalism did not still prevail on the island.

Our minds were soon set at ease, however, for Mecuisela,[2] the native Wesleyan preacher, took us in charge and escorted us to his home which he turned completely over to our use. His house was a single-roomed structure about 18 by 24 feet with woven reed walls, a corrugated iron roof and an earthen floor thickly covered with straw on which were laid native mats. By the dim light of the smoky hanging lamp we made out a small table and three chairs; so, drawing these together and spreading out the contents of our food boxes, and with Mecuisela looking on, the while talking and grunting to himself, we partook of a late luncheon during which we had opportunity to inspect further the contents of the room.

Along one side was an ancient chest of drawers and several small wooden cases, one of which we later found contained Mecuisela's preaching clothes consisting mainly of a black, ready-tied necktie, a white shirt and a sulu. The latter is the universal article of wearing apparel among members of the Fijian sterner sex and is simply a piece of cloth two or three yards long and about twenty-eight inches wide which is wrapped around the waist and the free end tucked in so that the garment maintains its proper position on the body. An ancient Seth Thomas clock hung on the wall with several photographs of the preacher and others. Highly colored pictures of the Last Supper, the Barren Fig Tree and the Defiled Temple adorned other wall space; an old shotgun was suspended from a nail. In one corner of the room, snuggled down in the straw, was a sitting hen. But the *piece de resistance* was a huge bamboo bed 5½ by 12 feet covered with straw

[2] Pronounced Methuselah.

and over which were placed eight native mats. A canopy of tapa cloth and a mosquito net completed the hangings.

Since it was late and we were all tired we tried not to think too much of the scorpions, centipedes and fleas that might be lurking between the mats and so the four of us, without removing our clothing, lay down on this huge bed where we passed a night of fitful slumber. The lali was being beaten to call together the villagers for divine service and at eight-thirty parson Mecuisela departed to conduct it. A little later the notes of one of our familiar hymns drifted in to us from the meeting-house. The next morning Mr. and Mrs. Welch went on up the river while Mrs. Stoner and I remained behind for a day of collecting.

The village of Viria, which is typical of many another native village in Fiji, comprises about sixty people who live in a miscellaneous assortment of houses and hovels arranged in the form of a hollow square. The greensward in the square is kept short by the pigs, goats, chickens and the tramping of many bare feet. A general store, managed by a European, supplies most of the simple needs of the villagers.

Unfortunately for me, a drizzling rain had set in and it continued with slight intermission throughout the day. However, I started out in search of insects and when the rainfall became unusually heavy I sought shelter under the dripping trees.

In the evening a meke, or native dance, was put on for our benefit in Mecuisela's house. About eight-thirty three native girls with leis of flowers around their necks and wrists, took a sitting posture on the floor in front of us and to the accompaniment of a small lali beaten by a boy, and with wierd singing carried on in a high pitch by all, the "dancers" indulged in various graceful movements of arms and hands. Lui said that they were singing of recent happenings in the village. After a half-dozen songs they clapped their hands together sharply to indicate that they had finished the first number of the program. Meanwhile, the parson and a number of natives had entered the house; the latter stowed themselves in various out-of-the-way places on the floor where they viewed the dance and the members of our party who, I feel sure, were more interesting to the natives than were the dancers. On completion of a dance the commendation of the on-lookers was expressed by the words "Vinaca, vinaca," which means "Good, good." Dance followed dance until we were more than satisfied and to further express our satisfaction and the dancers' as well we offered a small gratuity after which they all departed leaving us for another night's rest on Mecuisela's couch.

Next morning we went about the village visiting the natives and taking photographs. Most of the native Fijians are very glad, indeed, at times anxious, to pose for their photographs. The Hindus, on the other hand, will not permit it. At eight o'clock the whistle of the "Tomy" warned us that she was about to leave. So, escorted by the ancient Mecuisela and most of the villagers we descended the slippery bank up which we had come two days before, to the wharf. Again we boarded the decrepit launch and with the farewells of the natives in our ears and Mecuisela almost in tears we chugged away leaving behind these simple people and taking away pleasant memories of our visit with them.

BIRDS

In accordance with expectations, the species of birds of Fiji are quite different from those inhabiting North America, though representatives of certain families are common to both regions.

The following characteristics of the Fijian avifauna as I have observed them from Vitilevu and the near-by islands and seas seem to me to be worthy of mention.

The total number of species on and about the island is only about seventy-five, of which less than twenty are "water birds." The surprising paucity of marine forms was constantly brought to my attention.

No one species of native bird is markedly abundant. The dense bush offers a comparatively safe retreat for some species but even here the number of individuals falls below what one might be led to expect. There is present a goodly number of introduced species which thrive well.

The small number of nocturnal and crepuscular birds calls for special mention as well as the limited number of strictly raptorial birds and the total absence of woodpeckers.

As the steamer approaches the entrance to Suva harbor through an opening in the great barrier reef, one sees a few crested terns (*Sterna bergii*) perched upon the floating buoys and signal posts. Perhaps also a bluish dot here and there along the shore proves to be a blue heron or "Belo" (*Demiegretta sacra*), a species which I found later in the marshy mangrove swamps. An occasional tropic bird (*Phaethon æthereus*) may have been seen a little farther out to sea. With these exceptions water birds are not plenti-

Border of Botanical Gardens, Suva (See page 142)
Coconut Palms, Makuluva (See page 143) (Photos by Wylie)

PLATE XXIV

On the Waimanu River
Crossing the Waidena River (See page 149) (Photos by Wylie)

ful. One misses the usual number of gulls found in bays and harbors.

Almost immediately on landing, the attention of the visitor is drawn to small flocks of strong-flying brown and white birds with a patch of white in the wing and which are possessed of loud and rather harsh, discordant cries. In the coconut and mango trees, on and about the buildings adjacent to Victoria Parade, the principal thoroughfare of the city, along the beach at low tide, in the more or less cultivated regions, everywhere, in fact, the hardy, inquisitive and belligerent mynah (*Acridotheres tristis*) is found. This species was introduced into Fiji many years ago in an attempt to control insect pests but it has found other food more easily available and so agricultural interests have not benefited by its presence. It partakes somewhat of the characteristics of the European house sparrow with respect to nesting habits, fecundity and adaptability and, in general, is held in ill repute by natives and Europeans alike.

"Indeed, an interesting analogy prevails between the Asiatic people and the Fijians on the one hand and the Mynah and the native Fijian birds on the other. The hardier and more aggressive Chinese and Indians, the latter introduced in great numbers into Fiji largely under the indenture plan of labor, are slowly but surely forcing down the Fijians who, though seemingly powerless to help the situation, hate the newcomers most heartily; the more so as they see business and property along with wealth and all that goes with it gradually coming into the power of the invaders. So it is with the hardy and aggressive Mynah as compared with the native birds. This crafty and quarrelsome introduced species stands back for no native bird and is gradually outstripping the native species in the struggle for maintenance. The same condition prevails in the Hawaiian Islands and may become true in New Zealand.

"The Mynah is a trimly built bird about ten inches in length with the upper parts, breast and sides brown, the head and neck black, the lower parts white and a white bar on the wings. The short blunt bill is yellow and there is a bare patch of yellow skin behind the eye. Mynahs are mainly terrestrial and gregarious; they have a considerable variety of notes and are great imitators. Their nests, loose bulky affairs, are sometimes placed on the branches of trees but more often in gutters and unused chimneys of houses, the birds partaking in this respect of some of the bad traits of the European House Sparrow. . . . .

"About twelve miles northeast of Suva and four miles off shore is situated the little island of Makuluva upon which is located the Government Quarantine Station. On this bit of disintegrated coral about eight acres in area where temporary quarters were established by us, Mynahs are common and a number were taken for specimens. The birds usually go about in small flocks and after once being shot at they become very wary and difficult of approach. When wounded they often fly some distance before coming down, sometimes alighting in the tops of the coconut palms where it is impossible to secure them.

"Although apparently successful in the struggle for existence the battle is not always in favor of the Mynahs for they too have their enemies among which may be mentioned man and certain parasites. The prevalence of parasitism and the extraordinary degree to which it may be developed is well illustrated by one Mynah taken on June 19, 1922, which served as host for the following parasites: several thread worms between the conjunctiva and the cornea of the eye; both eyes were infested and more than a dozen worms each measuring from eight to ten mm. in length were taken from the two organs. Some of these worms have been submitted to Dr. B. H. Ransom, Chief of the Zoological Division of the Bureau of Animal Industry, United States Department of Agriculture, who pronounces them to be a species of *Oxyspirura,* probably new, and adds that the Mynah forms a new host for representatives of the genus. In addition to these parasites this bird bore two small owl flies and two small biting lice. Eggs of the latter were also discovered and probably other individuals of all three types of parasites escaped observation. Another bird examined contained a large round worm in the abdominal cavity. Other Mynahs were found to be infested with these parasites though none other examined was so markedly afflicted as the individual above mentioned.

"Notwithstanding a considerable diversity among the major parasites attacking them and the presence of other natural and unnatural enemies these vigorous birds not only survive but even seem to increase.

"In conclusion, by way of summarizing, it may be stated that the factors which seem to contribute to the success of the Mynah when introduced into a new country are its audacity, hardihood, adaptability, wariness in eluding enemies, its omnivorous food habits and its selection of breeding places. After all, one can not help admiring this bird."[3]

In a communication which I recently received from Dr. Casey A. Wood of Chicago, Illinois, who has just returned from Fiji, there is included a transcript of a report which he made to the Colonial Secretary concerning the mynah. The comparatively few stomach examinations which he has made reveal few insects and in areas where Koster's curse abounds he found that the birds had been feeding upon both the seeds and soft parts of that exceedingly noxious plant pest. The seeds were unaffected by the digestive juices of the bird which seems to act as a disseminator of undesirable plants and "a very poor exterminator of (possibly) harmful insects."

The beautiful Australian diamond-bird (*Pordolotus* sp.) has also been introduced into Fiji where it, too, seems to thrive unusually well.

One of the most familiar birds in Vitilevu is the little finch-like ploceid, *Erythrura pealei*. Its vivid greenish coloration is set off by bright crimson on rump and crown. This bird frequents the more open districts where it feeds very largely on seeds but where also, it serves as a target for the sling-shots and air rifles of the Hindu and Fijian boys.

Another common species in and about Suva is the noisy, grayish, caterpillar-shrike, *Lalage pacifica* (Campephagidæ).

The need for more nocturnal and crepuscular insectivorous birds in Fiji is evident to those who have conditions there at heart and some attempt will probably be made in the near future by the Colonial Department of Agriculture to introduce certain Australian species for the purpose of controlling noxious insects, particularly night-flying moths. During my stay in the islands, by invitation of the Acting Director of the Colonial Department of Agriculture, I participated in a conference dealing with the proposed issue. It is felt by some that, since Fiji is almost without night flying insectivorous birds, a few judiciously selected importations from the sister colony 2,500 miles away will supplement the good work of the native diurnal forms. The three birds which seem to offer the greatest possibilities are the white-throated night-

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[3] Stoner, Dayton. The Mynah—A Study in Adaptation. The Auk, XL, No. 2, 328-330, 1923.

jar (*Eurystopus*), the morepork (*Podargus*) and the boobook owl (*Ninox*).

I strongly advised them to proceed slowly in this matter, not to tamper too much with Nature's balance and not to introduce new birds, no matter what beneficial qualities they might appear to possess, until complete and exhaustive studies of food, breeding and other habits in their native home had been made; careful consideration should also be given to the practicability of securing and transporting specimens as well as the likelihood of their survival and relation to other animals in their new home. Importation of a new species of animal into any country is a serious and often dangerous business.

Of diurnal insectivorous birds, three species of muscicapids, *Myiagra* sp., and *Rhipidura layardi,* the meliphagids *Ptilotis procerior* and *Myzomela jugularis,* the swift, *Callocalia spondiopygia,* the graceful black and white wood swallow, *Artamus mentalis,* and the white-eye, *Zosterops flaviceps* are among the commoner forms.

In the higher and more wooded portions of the island doves of several genera are to be found, the two commonest ones being the Fijian "Sogi dina" (*Columba vitiensis*) and the "Coge" or barking dove, (*Chrysoenas luteovirens*), whose call is more or less resonant and ventriloquial. The former is occasionally taken by the natives for food.

But three species of raptorial birds occur on Vitilevu, the falcon (*Falco lunulatus*) and the "Lulu" (*Strix lulu*) apparently being the commonest representatives about Suva.

Along the beaches and fresh-water streams the kingfisher (*Halcyon sacra*) is fairly common. It is green above and tan below and although considerably smaller than our own representative of this family one can not fail to identify it by its characteristic actions.

The total absence of woodpeckers in the Fiji bush is one of the most notable departures from the usually prevalent conditions existing in our own woods.

As a general proposition, birds on Vitilevu are less abundant both from the standpoint of number of individuals and number of species than one would expect in view of the seemingly favorable conditions; only about thirty-five forms, both native and introduced, are at all common on the island and adjacent seas. Several species keep well into the bush and so are seldom seen. Little if any damage is done to crops or cultivated fruits.

There are no native predaceous mammals, no snakes and few predaceous birds on Fiji. The principal enemies of birds—the mongoose, the wild pig and the rat—have all been introduced by man; and he, as is the case in other places that could be mentioned, is one of the chief offenders against the rights and liberties of the birds themselves. Neither the Indians nor the Fijians observe, to any appreciable degree, methods of conservation and the laws relating to the killing of birds are not strictly obeyed.

TERRESTRIAL ARTHROPODS

Before considering the insect fauna of Fiji in any detail a short general summation of its characteristics as they have occurred to me may be worthy of mention.

Those who have made a study of the affinities and relationships of Fijian insects find that they are very similar to the New Guinea insects and it would seem, therefore, that a considerable proportion of the Fijian forms has been derived from those of New Guinea which lies 2000 miles northwest of Vitilevu and is the largest oceanic island in the world. This theory seems to be borne out by the relationship apparent between the insects of Tahiti and Tonga with those of Fiji for the insects of the former islands are more like those of Fiji than like those of New Guinea and have probably spread to those islands from Fiji. Since the Tongan and Tahitian insects are closely allied to the Fijian and since the Fijian and New Guinea forms are, in turn, closely allied, it follows that the archaic ancestors of the more recently evolved Tahitian and Tongan forms originally came from New Guinea.

If this be true it is reasonable to suppose that the smaller forms would be more easily transported from place to place than the larger forms and this would, in some degree, account for the generally small size of the Fijian insects. Winds, currents, ships, floating timbers, the feet of birds—all no doubt, have had a part as distributing agencies.

Although the size of most Fijian insects is small and the number of conspicuously colored forms is few, a considerable variety is represented, the flies (Diptera) and true bugs (Heteroptera) perhaps being most abundant in number of species.

A considerable number of the species and genera are peculiar and are found nowhere else in the world. As evidence of this I may cite Dr. W. M. Mann's recent paper on "The Ants of the

Fiji Islands,"[4] in which forty-seven of the seventy-eight forms discussed therein are described as new. Thorough collecting and a large amount of taxonomic work still remain to be done in most groups of Fijian insects. It is hoped that our collections and the reports which will be published on them will go some way toward making known the entomology of the region.

The comparative paucity of beetles (Coleoptera), the abundance of cockroaches (Blattidæ), so far as individuals are concerned, and the small number of four-winged flies (Hymenoptera), exclusive of ants which are exceedingly abundant, is worthy of comment.

While spiders (Arachnida) are not insects, the smaller ones in particular make up a conspicuous part of the terrestrial arthropodan fauna of Fiji.

A more detailed account of the occurrence, abundance and habitat of some of the commoner Fijian insects and other terrestrial arthropods as well as incidents which pertain to their taking may be of interest.

Of the lower forms, spiders are exceedingly abundant, particularly small ones. A large yellowish species similar to our Epeiras is common in Suva and its huge webs extend from the trees to the telephone wires and perhaps over several of the latter with here and there one of the spiders resting on the delicate, glistening strands.

A few scorpions were taken at Walu Bay and at Viria. They frequent damp places in the woods and are often found under the loose bark of decaying trees. The thatched roofs and walls of the natives' houses often harbor them in numbers.

Millipedes are common in damp places wherever some shelter can be found. At the Tamavua quarry I saw a very large one dead; it measured seven inches in length and one-half inch in diameter. Under the rocks at the bottom of the valley along the Tamavua river near the quarry a moderate sized species was common. When picked up it coiled quickly, at the same time emitting a large amount of a brownish and very pungent fluid from pores along the sides of the body. This fluid looks and smells like tincture of iodine and stains the skin like it and certainly must be an effective means of defense. A small blackish form with white spots along the sides is not uncommon in moist woodland.

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[4] Bulletin of the Museum of Comparative Zoology, LXIV, No. 5, 401-499, 1921.

Centipedes are of frequent occurrence but I saw no large ones; a moderate sized species is found in woodland, under dried cow dung and in piles of newly threshed rice.

Practically all the orders of insects are represented and it is interesting to note that at least some of the forms that occur in Iowa occur also in Fiji. With the continual increase in the acreage given over to cultivation, a corresponding increase in damage done by insects has become apparent, and control measures for certain cane, banana and coconut pests are now being advocated.

An illustration of the extensive distribution of one of our simplest insects is afforded in the well-known fish-moth (*Lepisma saccharina*). This thysanuran occurs abundantly and its destructive qualities are as apparent in Fiji as in the United States. Springtails (Collembola) also, are very common under rocks, sticks and logs in damp places and often in turning over such objects a perfect shower of these little insects greets the collector. They are furnished with a delicate, flexible, chitinous structure near the tip of the ventral side of the abdomen by which they can leap several inches into the air; it is from this structure that their common name is derived.

Owing to the abundant rainfall in the vicinity of Suva there are many small streams and ponds which offer excellent breeding places for dragon flies (Odonata). At Navua in particular, members of this group were numerous.

The commonest neuropteron is the lacewing (*Chrysopa sanvitoresi*) which is often found on guava. The larvæ feed on scale insects of which something like twenty species of these more or less destructive forms are found in Fiji. Another small brownish chrysopid was taken in the dense bush at Tamavua.

The order Orthoptera is well represented. Locustids in all stages were common at Navua on June 29. A large conocephalid was taken frequently. In fields bordering cane patches and on the high para grass which has been introduced into Fiji to furnish food for live stock, and which flourishes to a marked degree along streams and drainage ditches, a large green acridiid occurred in numbers. Several other species of grasshoppers were taken. Grouse locusts frequent the vegetation of roadside ditches and damp situations. I came across no particularly striking forms.

Under the loose bark on trees and dead stumps a big black brachyelytrous cockroach is common. At Makuluva, Nukulau, Tamavua and Viria it was encountered in all stages of development. The insects are very active and shun the light. When disturbed they discharge with some force a fine column of fluid with a very pungent and evil odor. In the bush at Colii Suva on chipping away the loose bark of a tree, four or five of these black fellows scurried away quickly but before doing so one of them discharged with a distinct hissing sound a stream of this ill-smelling fluid into my eye. Its presence caused the optic to burn and smart terribly and to water profusely for several minutes. This fluid is irritating even to one's skin for a drop of it which struck me on the face produced a distinct burning sensation. The Fijians sometimes call these insects "Maori bugs."

Hordes of crickets occur everywhere. A large black one (*Gryllus oceanicus*) is common under leaves, sticks, grass and debris—anything that offers them shelter. At Makuluva, on one occasion, I found a small hermit crab in the act of devouring one of these crickets. The crab had bitten into the prothorax of the insect and was making a meal of its contents. It seems probable that these little crustaceans which are extremely abundant along all the beaches of Fiji may exert a considerable influence on the insect population of the islands. A small blackish cricket with white legs is very common on Vitilevu; we found it on Makuluva also but far less abundantly.

At least two species of leaf insects, locally known as "guava bugs" (Phasmidæ) occur on Vitilevu but I was not fortunate enough to come across any and so could not test out the oft-described protective adaptations attributed to these forms.

A moderate sized earwig (Dermaptera) is abundant and generally distributed over Vitilevu. I believe that it is an introduced form.

One of the commonest representatives of the true bugs (Heteroptera) is the long, slender yellowish coreid (*Leptocorisa acuta*). On a side hill near Suva in the vicinity of small cultivated plots, I took from one plant of yangona (*Piper* sp.) at a single sweep of the hand net more than five-hundred individuals. The bag was literally alive with the bugs which produce a dull buzzing note while in flight. Another representative of this family, the obese blackish *Brachylybus variegatus*, is one of the most abundant insects about Suva where it frequents drying and decaying bananas on the trees. On June 13 we found it in all stages. The insect is not of great economic importance.

A small elongate, blackish lygæid (*Pamera* sp.) is not uncommon; another small grayish member of this family (*Germalus pacificus*) with a rotund thorax and reddish eyes occurs frequently.

On June 21 at Makuluva I found on a mula-mula tree and on the dried leaves beneath it a strikingly colored yellow and black pyrrhocorid (*Dysdercus insularis*) in all stages of development. Hundreds of the insects could have been taken in a very short time. Although the species is found on Vitilevu I never saw it again in such numbers.

Of the shield-backed bugs (Pentatomoidea) the shining black coptosomid (*Brachyplatys pacificus*) is the most common being found in greatest numbers on yellow hibiscus although it also frequents lantana, mile-a-minute, cyrtospermum and other plants.

The most striking member of this group is the highly colored, obese, exceedingly variable and sexually dimorphic form, *Tectocoris lineola,* which occurs most frequently on mula-mula trees growing, usually, near the beaches. On June 20 all stages were taken at Nukulau and Makuluva though young were more abundant than adults. Often, clusters of from five or six to fifteen or twenty of the metallic green and black nymphs clung to a tender twig from which they were extracting the juice. The broadly convex scutellum of the adult female is usually yellowish with four large irregular dark areas; the scutellum of the adult male is iridescent purplish with four blackish crescents. The species is recorded as an enemy of the larvæ of the coconut moth (*Levuana iridescens*).

Near Tamavua, I took, on a slender, smooth-barked tree with green and red berries, many nymphs and a number of adults of the trim-appearing and brightly colored scutellerid, *Lamprophara bifasciata.* The coloration of the bugs blended in so well with the fruit that they were exceedingly difficult to distinguish. In all, something like ten species of Pentatomoidea were taken on Vitilevu.

On several ponds and small streams about Vitilevu I took water-striders (Hydrobatidæ) and in a tide-pool at Makuluva I found a small marine form.

Of the Homoptera, the cicadellids or leafhoppers abound in some numbers in grassy situations, along woods and in fields. A small blue-winged ricaniid (*Euricania tristicula*) is quite common near woodland.

A number of species of scale-insects occur in Fiji and among these is the almost cosmopolitan, fluted or cottony cushion-scale (*Icerya purchasi*). It feeds on orange, lemon and guava but its presence here is, as yet, of little economic importance.

Although beetles (Coleoptera) are not abundant, a goodly number of small and inconspicuous forms occur.

The tiger beetle (*Cicindela vitiensis*) was taken on damp mud flats at Walu Bay and again later in low places near the Tamavua quarry.

In cultivated and semi-cultivated areas, along the edges of dense bush, and on roadside vegetation a small, bluish-black halticid (*Haltica gravida*) occurs frequently. Indeed, we came across this beetle more often than any other; it was most abundant on *Jussiaea suffruticosa*, some plants being almost entirely denuded of leaves by the beetles.

In the vicinity of cultivated plots, two species of chrysomelids, *Aulacophora fabricii* and *A. quadrimaculata* were particularly common; both are of some economic importance since they feed upon melons, pumpkins and other Cucurbitaceæ.

The yellowish coccinellid (*Coccinella transversalis*) is fairly common on roadside vegetation and in cultivated patches of taro, yams, etc. Both the larvæ and adults feed on plant lice.

Among the interesting introduced forms is the small red and black Australian ladybird beetle (*Vedalia cardinalis*) which feeds upon scale insects. A few specimens of this species were introduced from Australia into California about 1890 in an attempt to control the fluted scale (*I. purchasi*) which was very destructive to orange trees. The beetles multiplied rapidly and within a few years had checked the destructive scale to such an appreciable degree that since that time the damage inflicted by it has been only occasional and local.

Another coccinellid beetle (*Epilachna 28-punctata*) occurs commonly and we secured a good series. It is yellowish with fourteen black spots on each elytron and like others of this genus it indulges in a vegetarian diet, feeding upon various kinds of Solanaceæ.

One of the interesting entomological experiences which I had in Fiji was the opportunity to cultivate a more intimate acquaintance with a small, wood-boring, anobiid beetle which is often called "Death-watch". These beetles seemed to infest the timbers of our landlady's house in numbers and every night after the place had become quiet we could hear the regular tapping or ticking sound of the insects as they struck their heads rapidly against the sides of their burrows. Although this sound is supposed to be prophetic of a death in the family, I was unable to discover any evidence of such a catastrophe except one or two fowls which were sacrificed to satisfy our gastronomic cravings.

We did not take many weevils but at Nukulau a big grayish fellow (*Elytrurus acuticauda*) was not uncommon.

Butterflies (Rhopalocera) are not very common. In this faraway land it was a great joy to come upon a well-known representative of the group, the monarch butterfly (*Anosia plexippus*). At Walu Bay I found a black and white butterfly common enough. The right side of the tip of the abdomen is furnished with a yellowish, filamentous introversible scent gland which the insect extended rapidly from time to time seemingly in an attempt to discourage the approach of enemies. A distinct odor could be detected as emanating from this gland.

Moths (Heterocera), particularly night-flying forms, are fairly common and as agricultural pursuits gain in popularity some of these are likely to cause considerable damage. Of the insects in Fiji which have a distinct economic bearing, the coconut moth (*Levuana iridescens*) is one of the most important. The adult moth is of a metallic blue color with an expanse of about ¾-inch and looks rather like our Theclas. In the vicinity of coconut plantations and even on the very small islands of the group where coconut trees form volunteer growths, the moths are abundant. The damage is done by the larvæ which burrow into the great fronds of the trees, weakening them and when a good "blow" comes, these branches are torn off and the vitality of the tree is thereby reduced.

The two-winged flies (Diptera) are well represented. Strangely enough, house flies (*Musca domestica*) are not particularly abundant in Fiji and very few of the houses are furnished with screens. The stable fly (*Stomoxys calcitrans*) occurs on the islands.

Owing, in part, to the unusual amount of precipitation, mosquitoes are abundant and their breeding places are numerous.

Pools of stagnant water are frequently met with and even some of the plants harbor sufficient water among their branches and stems to allow the pests to breed. One of the most interesting places in which I discovered mosquito larvæ was among the bases of the stalks of a large-leaved plant (*Cyrtospermum edulis*) which looks something like our rhubarb. Mosquitoes of the malaria-carrying genus *Anopheles* are not found on the islands but the disseminators of yellow fever and filariasis (*Stegomyia fasciata* and *Culex fatigans*) are present in some numbers. Although I saw only a single instance of the disease known as elephantiasis, the form in which filariasis is most often exhibited, I was informed by the physician who has charge of a large general hospital at Navua, that this disease is widely prevalent in the Fijis.

Flower flies (Syrphidæ) are common, the genus *Xanthogramma* being well represented. A large horse fly (Tabanidæ), *Tabanus fijianus,* with yellow and black abdomen sometimes attacks human beings.

The fruit-flies (Trypetidæ) are represented by several species, one of which, *Dacus parsifloræ,* in the larval stage, attacks the fruit of several plants and causes some damage. Another small form with heavily-veined wings (*Oxyna parca*) is common.

The order Hymenoptera (four-winged flies, etc.) is exceedingly well represented but ants make up the largest share of the group.

The large yellow vespid (*Polistes hebræus*) is common everywhere and its pensile paper nests are often constructed in mula-mula trees and in bamboo thickets. On one occasion I inadvertently aroused a colony of the wasps in such a situation and, having heard of their effective defensive ability, I considered retreat the better part of valor and acted accordingly and hastily. At Colii Suva where extensive road surfacing was being done under the direction of Mr. Dawson Thompson, a European engineer, these insects caused no end of trouble by insisting on crawling into his rolled-up maps and tracings while they were resting on the shelves in his shack.

A number of the smaller representatives of this order are of value as natural checks on destructive insects by parasitizing their eggs or larvæ.

Ants are everywhere and exceedingly abundant in number of individuals while the number of species, as already indicated, is large. The formicid, *Pheidole megacephala,* is a general predator on other insects and probably does much to keep in control certain noxious forms of insect life. On Makuluva this ant was common under the loose and dried bark of dead trees. On one occasion I found eight or ten individuals co-operating in the carrying of a good-sized longicorn beetle.

At Tamavua a moderate-sized black ant was found in abundance on tree ferns. It had the peculiar habit of holding the abdomen bent forward over the thorax while at rest, but when running it was carried in the usual manner.

CHAPTER VIII

SOME EXPERIENCES OF A BOTANIST IN FIJI

By Robert B. Wylie

A kind invitation to join the Fiji-New Zealand Expedition organized by Professor C. C. Nutting in 1922 afforded favorable opportunity to see those distant lands. The party of six left Iowa City shortly before Commencement and returned to America early in September. I had desired for many years to collect class and research material from the tropics and to see the various economic plants of the great middle zone. Others have described the organization of this group from the University of Iowa, thus permitting me to limit my account to certain aspects of the work in Fiji.

We awoke on board the Niagara on the morning of June fifth to find the tropical island of Vitilevu, largest of the Fiji group, spread out in the morning sunlight. Before us stood the terraced slopes of Suva, its red roofs gleaming from under canopies of mango foliage. To the right, past the harbor's mouth, rolled the surf bordering the coral reefs,—a windrow of white foam stretching into the distance as though painted on the sea. On the left there rose from the palm fringed shore the verdant hills which merged into the softer green of the nearer mountains while purple against the sky lay the more distant ranges of the interior. To one who had lived most of his life on our corn-covered Iowa plains it was a dream come true to feel at last the atmosphere of a tropic shore. The landing amidst the bare-headed Fijians, turbaned Hindus, and helmeted Europeans; the peculiar faces, odd garments, and soft voices; the strange sights, unusual odors, and tropic breezes,—all gave reality to a scene that otherwise seemed to belong between the pages of a book.

The courtesies of government officials began with our landing, and their helpfulness was greatly appreciated by all of our party. Colonial Secretary Fell and his associates not only arranged quarters for us in government buildings, but gave us exclusive use of Makuluva Island as a base for our work. They aided us in securing launch, porters, etc., besides taking several members of the

Iowa party as guests on trips into the interior of Vitilevu Island. Mr. Harold C. Wright, Acting Commissioner of Agriculture, very kindly allowed me the use of a laboratory in the Chemistry building and through his knowledge of native plants and the Fijian language greatly aided me in my work.

Others of our party have discussed in their respective chapters the salient features of these islands. Without unnecessarily repeating their descriptions a few facts only are necessary as a background for the consideration of plants growing in the region. The Fiji group including outlying rocks and reefs numbers 250 islands lying between latitude 15 and 22 S. and therefore well within the tropic zone. Their small size and remoteness from large bodies of land give them a distinct ocean climate with a fairly uniform temperature. The larger islands are mountainous with extensive alluvial lowlands in places. Coral reefs account for many of the smaller islands and constitute a marginal breakwater off most of the shores. The total land area of 7435 square miles is chiefly contributed by two or three of the larger islands. Vitilevu, the largest, upon which the capital, Suva, is located, is nearly one hundred miles in east-west dimension and about sixty miles north and south with an estimated area of 4112 square miles.

The rainfall is somewhat rhythmic in distribution and with a wetter season extending from December to March, though even in the dryer parts there is scarcely a month without rainfall. The prevailing wind during the dryer part of the year is the southeast trade wind, which gives this side of the island a rainfall of about 110 inches, while the leeward side has less than half that amount, averaging perhaps 45 inches. My experiences were exclusively with the rainy side of the Vitilevu Island, in and around the capital city of Suva.

During my six weeks in the islands, June and July, there were many early morning rains, but though out daily on collecting trips I never encountered a heavy rain-storm in all that time. Their so-called winter weather was very mild, comfortably cool at night, and though hot during the day, the air was always tempered by the waters of the Pacific whose surf pounded on all sides of this island.

These islands, though long peopled by native races, are still comparatively undisturbed over great areas. On Vitilevu Island one encounters relatively natural conditions within a few miles of the capital and the interior of this island, except along the stream valleys, is perhaps infrequently visited by white men even at this date. Agriculture is well developed in the delta regions and along the larger rivers.

The vegetation on the rainy side is abundant and tropic rain forests occupy great stretches of country ranging back into the mountainous interior. It is estimated that the colony has about two million acres of forest containing many trees valuable for lumber, boat, and cabinet work. Some of these trees yield timbers of fine grain and capable of high polish. A favorite wood of the natives is their vesi (*Afzelia bijuga*) from which are made their war clubs, walking sticks, furniture, and ornaments. A few others are the Fijian kauri (*Agathis vitiensis*); island mahogany (*Calophyllum burmanni*); yasi (*Eugenia effusa*) used in boat building; and yaka (*Dacrydium elatum*) used for furniture and ship building. There is hope of developing export trade in the finer of their lumber products. In this connection it is perhaps worthy of note that the earliest trading with these islands near the opening of the 19th century grew out of a search for sandal wood. Later the demand for cotton, due to the scarcity arising out of the American Civil War, led to the admission of the Fiji Islands as a colony of the British Empire in 1874, upon petition by the organized government of the islands.

Of interest to one from the colder zone are their crop and fruit plants, all so different from our own. Agriculturally the islands are relatively undeveloped, though extensive areas are under cultivation. The delta plains at the mouths of streams are favorable areas for sugar cane and for pasture lands. Alluvial deposits along the rivers are given over to bananas of which there is a considerable export trade. Cotton is no longer grown, though the quality produced in parts is of the best, winning first place at our Centennial in 1876. Practically all the tropical and subtropical crops and fruits may be grown in the islands, but most of them are given but little attention aside from food plants for local use. Cocoanuts are grown extensively and the annual export of copra is about 20,000 tons. Bananas were exported to Australia in considerable quantity, but since the war Australia has interposed a heavy import duty, with disastrous results to this industry in Fiji. New Zealand is their best market at present, and bananas for Auckland or Wellington are cut from the stems and shipped

Tree ferns, interior of Vitilevu (See page 150) (Photo by Wylie)

PLATE XXVI

The "Gates of Namosi," Mt. Fell to right of house in center (See page 162)
View from Waivaka, Mt. Namosi in distance (See page 162)
Road-making in the Suva soapstone, near Colo-i-Suva (See page 137)
(Photos by Thomas)

packed in small wooden boxes from which they are retailed in New Zealand. Strangely enough bananas seem difficult to buy in Suva. I found but one shop where they could be had with any regularity. Apparently they are used less freely there than in our own country.

Sisal hemp, jute, cotton, tobacco, rubber, cocoa, pineapples, coffee, rice, limes, oranges, etc. are all capable of cultivation in these islands, but most of these are grown, if at all, only in an experimental way at the present time. Of course the natives make much of their taro, yams, cassava, and tobacco, but none of these enter into their exports, though all of them are important for domestic use.

A week spent with Professor Nutting on Makuluva Island afforded opportunity for the examination of coral reefs and what might be termed the strand vegetation of the shores. This tiny coral island is oval in outline, about 300 yards long and but 200 yards in width, and is only a few feet above the high tide level. At low tide the shelving shore is laid bare for nearly half a mile out, on three sides, and one may walk across its level surface containing numerous interesting tide pools. At the outer edge are the masses of living corals and over them pounds the surf with ceaseless roar. These coral terraces have a number of species of algæ, but the rocks are relatively bare and there were no large or conspicuous forms such as one finds in northern waters. The Corallines took high rank as regards relative numbers, and contribute to the formation of limestone, but formed no compact associations. Considerable quantities of *Sargassum* were beached on the windward side.

The shore was strewn with countless seeds, fruits, and plant fragments, and a little higher, above the shifting coral sand, I encountered numerous vines, chiefly legumes, some of these many yards in length, intermixed with grasses and younger trees. This association acts as a soil-binder as waves add to the land area. The palms, seemingly self-planted, were numerous, there being perhaps nearly a hundred of them on the island. A number of these were quite young, and in the sands were germinating seeds. The older palms were leaning quite uniformly to the northwest. Along the shore freshly buried fruits of cocoanuts contained seeds which were germinating. I noticed how careful the natives were not to disturb these potential palms. On one side of the island in pure sand I found young plants of mangrove started in a region where of course further growth was impossible for them.

With maturer conditions of soil various trees establish themselves, such as *Tournefortia argentea, Terminalia litoralis, T. catappa, Hernandia peltata, Calophyllum linophyllum, Drymispermum burnettianum,* etc. Of special interest were several pandanus trees with their conspicuous fruits. At the northwest corner of the building assigned to us for use as laboratory was a fine but solitary papaya tree (*Carica papaya*) in full fruitage. Since this species is diœcious and therefore could not pollinate its own pistils I wondered as to the possible source of pollen. A careful study showed that no other mature tree of the species was growing on this island, though at the north end was a young tree a few feet in height which apparently had never blossomed. The nearest possible source of pollen therefore was from Nukulau, a neighboring island somewhat larger than Makuluva, which was reported to have many papaya trees. In this case the pollen was carried across open water for a distance at least one mile, or if from the mainland, a distance of three miles. The fruits contained abundant seeds.

The greater portion of my time was spent in and about Suva, with headquarters at the Fiji Club. This comfortable club house occupied a hilltop overlooking the harbor and most of the town. Through the kind invitation of the officers of this club we were permitted to use their dormitory building and so we escaped the tediousness of hotel life. The secretary of the club, Mr. Clarence DeMouncey, showed me many kindnesses not the least of which was the privilege of being a guest on two occasions in his attractive suburban home. Here grew in profusion a wealth of cultivated flower and foliage plants which were the special pride of Mrs. DeMouncey. From Suva as a center we made numerous short excursions to adjacent "bush", semi-cultivated, and cultivated areas.

While in these islands I was interested to see the splendid work being carried on by Dr. S. M. Lambert, an American, working under the auspices of the Rockefeller International Health Board. He was engaged in a study of the hook-worm disease with which the peoples long resident in the tropics are so afflicted. Dr. Lambert was using carbon tetrachloride as a specific, and during the fore part of that year had treated over 25,000 cases, about 90% of whom were cured by a single dose. Thousands had thus been improved in health and vigor and this was reflected in increased labor efficiency and happier lives. In this way as the diseases of tropics are conquered the tremendous agricultural resources of these regions may be developed. The next generation will have to use the great middle zone and such work as Dr. Lambert is doing is a necessary forerunner of the full industrial development of the tropics.

The climax of our experiences was an eight day journey into the interior of Vitilevu island as the guest of Colonial Secretary Fell. His group included Captain Alan Lawrence, of Australia, and Dr. A. O. Thomas, Mr. Waldo Glock and myself of the Iowa party, together with numerous Fijians and a Hindu cook.

The first stage of this trip was down the coast by launch from Suva to Navua, a distance of about twenty miles. Going out at high tide we took the inside channel and rode for miles over most beautiful coral formations. The water was so shallow that in places the launch scraped bottom, and as the sun shone brilliantly we had a favorable view of these submarine growths with their darting fish of striking colors. There was afforded at the same time a general survey of the nearby shore with its low mountains clothed in green to their summits.

We were entertained that evening at a formal dinner given by the District Commissioner at Navua, and spent the night at a comfortable hotel situated on the river's bank. Early the following morning the party proceeded up the Navua River in flat-bottomed punts which were pushed along by slender "makita" poles in the hands of stalwart Fijians. In the lower stretches of the river through the delta district, travel was easy and two men each readily handled the boats. But by afternoon when we were pushing up between mountains, six and finally eight men were pushing mightily on each boat. No more interesting display of strength and skill than was shown by those splendidly muscled natives working happily in perfect rhythm, shoving the boats up over those difficult rapids. Only twice were we compelled to disembark though several times the Fijians were forced to wade and push the boats with their hands.

Noon brought us to the village of Nakuavu where we were received with great dignity by the head men of the village who conducted us to a bower tastefully decorated with palm and other foliage plants erected in honor of our visit. Within this enclosure were gathered the men of the village who received us with full formality. Their age-old ceremony centers about the making and serving of kava, the native drink which is prepared from the roots of the *Piper methysticum.* The powdered root is thoroughly mixed with water in a finely carved wooden bowl of perhaps four or five quarts capacity. The fiber is then removed by dragging a loose strand of bast through the mixture, wringing the fluid back into the bowl, and shaking out the fragments. This is repeated a score of times when the milky kava is cleaned and duly pronounced as ready to serve. During the half hour required for the making of the kava, half a hundred of Fijian men, seated on the ground, chanted a ritual in deep sonorous voices.

The master of ceremonies then presented a cup of kava to each of the guests in turn, and in order of their rank. On these occasions the kava is served in a half shell of a large coconut, which has been carefully smoothed. Some of these cups worn by long usage become lined with a precipitate like mother-of-pearl and these are greatly valued by the natives. I rather dreaded the ordeal of drinking the kava when my turn came, for courtesy compels one to take the bowl in both hands and to drink its contents without pausing for breath. When emptied the cup is set spinning on the mat towards the cup bearer who serves the next in order. I found the beverage not unpleasant to the taste. Kava is widely used by the natives and by many whites as well. It is non-alcoholic but undoubtedly possesses an alkaloid, as it becomes a habit with those who use it. We saw no ill effects or physical detriment following its use by natives, though we were informed that prolonged indulgence brought on a temporary paralysis of the legs, but the brain, fortunately, remains clear.

The afternoon took us still farther upstream and the evening found us welcomed to the village of Namuamua at the junction of the Navua river with the Wainikoroiluva. This was another pleasant village having the characteristic broad stretch of open grass with the houses grouped around this court. Ornamental plants such as crotons, dracænas, varieties of coleus and other flowering or foliage plants were grown about their dwellings in tasteful array. Numerous breadfruit trees with their marvelous leaves, splendid palms, and a number of shaddock trees with their yellow fruits stood near the houses. The shaddock resembles grape-fruit, though less pulpy, and are as large as a small pumpkin Seeing them for the first time one feels that he is looking at an orange through a magnifying glass.

In this village we were treated with great courtesy, given the exclusive use of some of the houses, but underneath all the formality we were very plainly objects of curiosity to the natives of the village. On the evening of our arrival there was in our honor a prolonged singing festival by the men of the village, their heavy bass voices uniting in a monotonous chant with a peculiar rhythm and most unexpected pauses, with here and there an exclamation or a groan-like ending which sounded most weird as it was borne to us across the tropic night. One felt that he was in the presence of the long past ages and could well imagine the feelings of captives in other days, awaiting the dawn which would bring the human sacrifice and the cannibal feast. While we were spared the boiling pot our sufferings were none the less acute for the singing continued that night without interruption until daylight, and was resumed the following evening at night-fall. At midnight of the second night, the chorus still proceeding with undiminished vigor, Mr. Fell sent an envoy to thank the singers, assuring them of our appreciation, and begging them not to put themselves to further inconveniences in our behalf. So we got some sleep that night.

This boat trip up the Navua with excursions out the following day along some of the smaller tributaries gave us a most favorable opportunity for close contact with a tropical rain forest. The trees were not as large as I had expected to find and were frequently spaced rather widely apart, but the whole formation was one vast tangle of vines and creepers, trees, shrubs, and epiphytes, —the whole constituting an almost impenetrable jungle through which we made no effort to pass, since travel by river permitted ready contact with its margins. Only when accompanied by natives armed with cutting knives for opening the way could a white man hope to make much progress through such a jungle.

A strenuous overland trip of ten or fifteen miles took us into the beautiful valley of the Waidina river. In its upper stretches the stream flows through a double fault valley bordered right and left by nearly vertical mountain walls, 1000 to 1500 feet in height, dissected in part into separate elevations. While rounded in many places the walls are here and there so nearly vertical as to be almost bare of larger vegetation, but the slightest irregularity gives anchorage to luxuriant growth and wherever the slope permits there are unbroken forests.

In this valley beside the clear river is the village of Namosi, one of the most beautifully located towns in the world. Approach to the village is through an avenue of orange trees well grown and loaded with fruit when we were there. Above and below where the flood plain widens are banana plantations under native cultivation. On the bases of the mountains are fields of taro, the major food product of the region. The houses are grouped in the form of a rectangle, around an open grassy space with the home of the head man across the end. From the edge of the village rises Mount Voma, 2500 feet in height, from whose top on sunlight days one may not only see most of Vitilevu Island but others of the group as well. Two botanists, Seeman and Horn, the one in 1860, and the latter in 1877 climbed this mountain, and their books give interesting descriptions of the views from its summit. On the other side of the valley the mountains are more sloping and are heavily forested.

Our two day stay there was an unending delight. The numerous trails and willing guides opened up to us a considerable area up and down the valley. My most interesting experience while there was a climb up the mountain valley to an altitude of perhaps five hundred feet where fern forests of considerable extent spread out. By following a native trail up past the taro fields I was able to get quite close to one of these groups of fern trees. It was however with the greatest difficulty that I made the journey from the path to the edge of this fern forest. I am sure that I spent more than half an hour of the hardest kind of climbing and sliding and tumbling, working my way through the jungle for one hundred yards into the relatively open association where the fern trees were dominant. I was rewarded by an inspiring view; standing there one could well imagine himself back millions of years in the Carboniferous period. The slender graceful stems of the fern trees (*Alsophila lunulata*) rose to a height of forty feet or more, and overhead their beautiful fronds made an almost continuous canopy of green. These leaves, each ten to twelve feet in length are singularly soft and they sway almost noiselessly in the breeze. Over considerable areas these fern trees constitute the dominant forms. They shade out the ground vegetation apparently, and many climbing plants have some difficulty in ascending the slender unbranched stems. I made a number of exposures and despite the fact that the films were carried for several days before development succeeded in getting some excellent negatives which are now most prized, with half the world separating me from beautiful Namosi.

With Mr. Thomas and Mr. Glock I was quartered in one of the native Fijian homes and we were much pleased, not only with the courtesy of our host and hostess who visited the house from time to time, but also with the neatness and attractiveness of the dwelling itself. Experience brought to my attention again the fact that the Fijians, men and women alike, know practically all their larger plants, and have native names for all of them. I was interested to note though, that they sometimes do not distinguish between closely related forms, which is not surprising since they often look much alike. For instance, they use the same word for *Marattia* and for *Angiopteris,* ferns which are similar but not, of course, identical. These wonderful Marattiaceæ abound in Fiji and have enormous leaves twelve to fifteen feet in length, though the stems are short and tuberous.

We were deeply impressed with the evident honesty of the natives. Our baggage, unlocked, lay in their houses during our stay, and clothing, cameras, binoculars, and other items of apparatus were left lying in their houses while we were away. Though they were fairly burning with curiosity, we saw no evidence that the Fijians ever touched our belongings. If, however, we indicated to them a willingness to show them anything they crowded around like eager children revealing that the immunity of our possessions was not due to lack of interest or curiosity on their part. It was at Namosi that Captain Lawrence threw away at night a worn out pair of tennis shoes which were tied together. Falling in the edge of the jungle the strings caught on twigs thus suspending the shoes a little way from the ground. We had traveled miles down the river the next day when a boy came running to us bringing the shoes we had left behind. That night Captain Lawrence again threw the shoes far out in the darkness, supposing he had seen the last of them; but again a native followed after us many miles to return the shoes to their owner. That night Captain Lawrence buried his worn-out tennis shoes and saw no more of them. Such experiences emphasize the probable truth of the statement that nowhere in the world is life and property safer than in the Fiji Islands at the present time. This is all the more remarkable as it is less than a hundred years since the first missionaries began their work among the cannibals of this group and but one generation since they came under the British government.

The return trip from Namosi was in part a repetition of the journey outward, but since the boats were going down stream travel by water was easy. The first stage of our journey was an overland tramp of about ten miles to a point on the Waidina river where punts were awaiting us. The further trip down stream to the Rewa river was through alluvial plains merging into the broad deltas bordering the river farther towards the coast. These bottom lands were pastured in many places with herds of cattle evidently of high grade and looking quite as sleek and comfortable as any to be found in our Iowa pastures. One could not pass through these rich areas of relatively cheap land, with ready means of transport to the sea, without thinking of the wonderful possibilities for the development of dairying in that region.

Reaching the Rewa we took launch down to the home of the District Commissioner, Mr. Stewart, who entertained us most splendidly at his residence. After days in the wilderness the numerous courses served, spotless linen, glittering silver, and faultless service of a British formal dinner offered marked contrast to life with the natives. The situation was not without some embarrassment for us Americans however, as we were still in khaki and rough shoes, and had not anticipated such formal occasions in making our plans for this trip into the wilderness. A little farther down stream we took automobiles to Suva, from the region of Nausori.

The others of the Iowa party sailed for New Zealand on July 4 but I remained a few days longer in order that I might avail myself of an invitation from Mr. Harold C. Wright, Acting Commissioner of Agriculture, to accompany him on a four day walking trip into the region immediately north of Suva. This was a most interesting experience since we traveled for the most part over ancient Fijian roads, some of them having doubtless been tramped by the barefoot natives for thousands of years. We passed the village of Tamavua, ate lunch at Tholoisuva, and from the neighboring hill enjoyed an inspiring view of the Waimanu River valley and the numerous series of hills and mountains beyond. Descending to this river and passing upstream a few miles we reached the native village of Vatuvula. We were quartered for two days there in the home of a native preacher who kindly gave up his house to us. Excursions from this village were made up stream one day and into the forests on another. Here I saw for the first time near at hand the Fijian kauri (*Agathis vitiensis*). While not comparable to the more noted species in New Zealand they are nevertheless beautiful trees. We found here also *Dacrydium,* another southern gymnosperm. On both this trip and the one preceding we saw many "candle nut" trees (*Aleurites triloba*), so named from the fact that the seed is so rich in oil that it burns with a bright light when ignited. I believe these were formerly an article of export from the islands. The fourth day of our journey was involved in the return trip which we shortened by taking a boat down the Waimanu, and motor cars when once we reached the paved roads. I appreciated very much the kindness of Mr. Wright in arranging this trip for me.

The concluding days of my stay in Fiji were busy ones with packing and farewell calls upon those who had shown us so many favors while on their island. On the evening of July 12 I went on board the Navua and shortly before sunset we put out to sea, starting for New Zealand. As beautiful Suva faded into the distance and the twinkling lights were finally lost in the night I watched the mountains outlined against the western sky and wondered if ever again it would be my privilege to see this delightful region. Memory will always hold, however, with constant delight, the soft sighing of the trade winds through the palms and the fern trees, the distant roar of the surf, and the happy voices of the natives. Nor can I ever forget those Britons who, half way around the world from their loved England, watch and serve this far distant bit of their empire.

CHAPTER IX

EXPERIENCES OF A GEOLOGIST IN THE FIJI ISLANDS

By A. O. Thomas

The writer was a member of the University of Iowa scientific expedition to the Fiji Islands and New Zealand during the summer of 1922. The purpose of the expedition was to secure zoological, botanical and geological museum and classroom material and to gain first-hand knowledge of other parts of the earth—a very valuable asset as every teacher knows. The Fiji islands are noted for their luxuriant tropical flora and for their famous coral reefs. The relation of the latter to the geography and geological history of the group has been a subject of much investigation. Moreover, the Fijians themselves present a never-ending source of interest.

The Fiji archipelago is made up of a chain of far-flung islands some two hundred in number. They are arranged in the form of a crescent hundreds of miles across yet on a map they occupy but a dot on the vast Pacific. Eighty of the two hundred are inhabited; each of the others is but a few acres, more or less, of bare rock or coral sand. Vitilevu, the largest island, is eighty by one hundred miles in extent and has an area equivalent to about a dozen counties in Iowa. It lies within the crescent and toward its western horn. The group is astride the one hundred eightieth meridian. The international date line formerly passed through a village on the island of Taviuni in which a canny Scotchman is said to have kept a tavern built across the line. The bar at the west end ran till midnight Saturday, closed promptly, while the one at the opposite end opened, for it was still Saturday there. Sunday violation was thus avoided. The date line is now in the open ocean far to the east.

At dusk on the day of June 3-4, we sighted the sporadic outpost of the Fiji group and during the night slipped quietly through Nanuku passage into Koro sea within the crescent. Vanualevu, the second largest island, was on the right; Vitilevu, with its encircling coral reef was ahead. This great coral platform, miles in width, is trenched by a tortuous passage leading to the commodious harbor of Suva, the capital. Only experienced pilots can negotiate the channel and occasionally a vessel is grounded in a storm as a number of rotting hulls testify.

The sky line of Vitilevu is rugged but not wild. Joske's Thumb and various other peaks stand out near shore while the crests of the interior ranges are low on the hazy horizon. Irregularities are subdued by heavy forest and indentations of the shore line are concealed by swamps densely crowded by mangroves and other halophytes.

At the pier we were met by government officials who made our entry a mere formality. At the same time we were accorded a most hearty welcome, and every detail regarding our welfare and comfort had been anticipated and looked after most carefully. Colonial Secretary Mr. Fell, his able representative Mr. Pilling, and all the government officials were most helpful, cordial, and courteous —to all of them we owe much more than we can ever hope to repay.

A day or two sufficed to establish ourselves, first at the attractively situated, and beautifully surrounded Grand Pacific Hotel, and finally, in bachelor quarters at the quiet comfortable buildings of the Fiji Club on the hilltop. One can never forget the view from his window across the harbor to the white crested breakers on the edge of the barrier reef miles away, or to the hazy tops of the inland mountain range to the right. Tree ferns and cycads rustled outside the ever open window, strange-voiced birds chattered in the crotons and hibiscus, while a bare-footed, condescending Hindu servant anticipated every want. Yes, "tomorrow we get London mail, sir,"—the *Times* were a month or six weeks late but it mattered little—no one was in a hurry—"and there may be a letter from home."

The white people of Suva are cordial, hospitable and quite friendly. They are largely bankers and shippers, planters and storekeepers, professional men and government servants in many capacities. They have followed the Union Jack around the earth. They are world citizens. It was a pleasure to know some of them intimately in the informal atmosphere of the Fiji Club rooms.

I had the pleasure of having associated with me Mr. Waldo S. Glock, a graduate student from the University. We tramped over many a mile of Fijian road and jungle, and together we enjoyed a bit of scenery or discussed some geological feature. Many pleasures were increased by sharing them; many a problem was more lucid after a stimulating field discussion; burdens and difficulties were halved by coöperation.

Suva has well kept streets, there is road material a-plenty, and labor is cheap. For some miles out there are good metalled roads but beyond these is the bush. A drive out on the Tamavua road, now in the process of construction, illustrates the value of a good highway. Good grades are established, sharp turns are avoided, and an excellent road bed covered by a good surface metal is laid. In the vicinity of Suva a soft, shaly rock, locally called "soapstone," is the main underlying stone. It is not durable as surface metal hence the greatest problem is to secure hard rock that will stand traffic. Such a rock was found in the side of a deep valley which was located only after weeks of traversing the jungle by the engineer, Mr. Seeley. The rock he found is a hard bluish-black basalt occurring in typical, polygonal, basaltic columns below a reddish phase of the soapstone. The face of the rock metal quarry at time of our visit was sixty by seventy feet. The stone is lifted to the crusher by steam power over a sloping cable to a height of approximately three hundred feet at the side of the Tamavua road. We heard some criticism on account of the expense of lifting this rock but as a matter of fact the Public Works Department feels fortunate in having so good a quality of road metal in the soapstone district. From the planter's point of view the extension of metalled roads to the interior and finally to the north coast is of immediate importance in developing the island. From the standpoint of the natives opening up the bush will gradually convert their extensive communal holdings into pasture and canefield. Then, too, the white man's ax will rapidly denude the forested areas unless rigid timber regulations are enacted. From another angle, road construction furnishes employment during slack seasons for the thousands of Hindus who live on freeholds in the vicinity of the plantations. The laborers on the Tamavua road work in gangs, by nationality. They are very picturesque in their distinctive costumes or in some cases almost lack of costume. Light-hearted Fijians in one gang, Samoans in another, Hindus of one caste next, then of another caste, darker and beturbaned. "Salaam, sahib," they greet as one passes. We wonder how such slight frail-looking men can handle the large blocks of stone in the hot sun.

Near Suva at the upper end of Walu Bay we found men employed taking out a hard, tough limestone apparently of Tertiary age. The stone is used for road metal in and about Suva. They call the product "yellow metal." It is coralliferous and contains a few mollusc shells in places. The foreman showed us several large, triangular teeth of the Tertiary shark *Carcharodon* which he had found in the quarry. These teeth are fully five inches long and an inch thick at the base. Above the gum line they are covered with a hard, glossy enamel and the serrated cutting edge is as keen as a well-kept band saw. What formidable jaws bearing scores of these teeth their ninety-foot possessors must have had! There are great caves dissolved out of the stone suggesting that it has been well above sea level during a good part of the time since it was formed.

The foreman of the road workers was a Welshman named Edwards and when the writer dropped a word of greeting in his boyhood tongue a look of surprise, then delight, passed over his face. We must have a cup of tea. A servant was dispatched for the tea-billy and cakes. He recited a story of a sea voyage to Ceylon as a boy, of service in the South African war, and now he is settled in a little home in a suburb of Suva. A dusty photo of his childhood home at Llangollen was brought out; his mother lives there now. As we left he presented Glock with a balaka walking stick, then fondling over two or three of his finest he handed me one of yaro. Would I not be some day in Llangollen and could I not leave the stick with mother—a commission which I devoutly hope to carry out. A tear ran down his face as we bade good-bye beneath the rain-tree.

A walk to the top of the hill beyond the Signal Station in Suva brought us to the site of the old fortified village of the Fijians. There was a wonderful view of the harbor and a lookout over the lowlands on three sides of the hill. There is little to recall the old village except an enormous quantity of bleached sea shells. At first we thought it a shell marl of marine origin but the underlying black loam precluded that. It was a kitchen midden. The spot is 250 feet above the water of the bay and many miles from a good tide flat where such shell-fish abound today at least. We could imagine the Fijian women trudging up the long hill with basket-loads of them for food. The list on the menu is a long one: *Arca, Cardium, Macoma, Perna, Ostrea, Spondylus, Tridacna,* *Strombus, Trochus, Turbo, Pteroceras, Conus, Oliva, Cerithium,* and many others. As we dug in the refuse we half expected to find a human bone suggestive of an occasional cannibal feast. Bits of charcoal and pottery were the only finds.

The largest river in Fiji is the Rewa. This stream has developed a wide delta deposit over a part of the broad coral flat to the west of Suva. The mud from the river doubtless affects life on the flats for some distance out to sea. Well out from the mouth, or mouths, of the Rewa are two islands, Nukulau and Makuluva. The former is the site of the quarantine station for Fijians and East Indians. It is wooded, larger, higher, and more inhabited by birds and insects than is Makuluva. A brief walk along the beach opposite the dock showed that the shore shells are chiefly bivalves rather than univalves as is the case at the other island. Arcas of two or three kinds were very common. A fine banyan tree, a breadfruit, a pandanus, and three majestic tamarinds form the background of the quarantine buildings which are under the care of a real character, a Mr. Sadler. He has three fine dogs one of which dives for and catches fish, brings them ashore, and deposits them at his master's door!

Makuluva is a typical coral-sand island located on the flat farther out than Nukulau but still a mile or more inside the barrier reef. The flats are a wonderful sight at low tide. They extend for many miles inside of and parallel to the barrier. These hundreds of acres are dotted with shallow tide pools in which thousands of small forms seek refuge until the return of the tide. Serpent stars, sea-urchins, prawns, crabs, eels, small colored fishes, molluscs, and so on, abound. Toward the edge and near the surf line are great heads of *Orbicella, Porites, Meandrina, Pocillopora,* and other coral of many brilliant hues.

Acres of slimy algæ occur in places. Tunnels and holes bored by sea-urchins, cross channels fretted out by the coming and going tides, and loose coral heads impede one's progress; five-rayed starfish of the deepest ultramarine blue are common, a steely-blue to black holothurian lies helpless among the rocks, one's foot just misses the trap of a *Tridacna,* an innocent looking prawn gives a shock like a pistol crab, a savage and aggressive moray eel claims the right-of-way as one turns over a stone, an innocent little fish gives the hand a painful sting, a "sea-scorpion" with its hundreds of sharp setae is allowed to go in peace, a nudibranch of gorgeous orange, red, and gold slowly swims off with a strange undulatory motion; from a broken rock unwinds a worm, at first a few inches, then a foot, two feet, then by the yard—collect what you want and leave the rest; a big shell *walks off*,—it is simply a large, red, hairy hermit crab moving his house. At one place the writer turned over a flat coral head three or four feet in diameter. There was the usual scurrying to cover of crabs and fishes, but imagine the surprise when there rolled off of the up-turned stone two beautiful comatulid crinoids four to six inches across. Their arms and other appendages were most attractively barred with yellow, white, and dark bands. These rare animals were the high water mark of that day's collecting. But the tide returned, ankle-deep, then knee-deep; our rapidly diminishing island and laboratory were a half mile away and the water to our arm pits before we got the collecting pails to land.

This great tide flat with its teeming life is but the repetition of another flat which is now close to two hundred feet higher as the Tertiary limestones mentioned above testify. Streams have carved the old elevated platforms into deep valleys and sloping hills and its landward edge is many miles from the present shoreline. Intermediate diastrophic movements have somewhat complicated the story as the Suva soapstone and other evidences seem to imply.

An opportunity to see the gorgeous living corals of the fringing reef and those of the deeper waters inside the barrier reef was had in a ride at high tide in the "Alma S." a staunch gasoline boat drawing about two feet of water, and piloted by her owner, Mr. Smoothey, a very efficient skipper. The run was from Suva to Navua at the mouth of a river of the same name. Wonderful reefs of immense purplish heads, some solid, some branching, flexible corals, sea-urchins and gaudy reef fishes abounded in the clear water. A species of medusa, individuals a foot across, purplish above with brownish tentacles below, was very common, some at the surface, others ten to twenty feet down. We passed through and over them for miles. The boat finally reached the Navua dock and none too soon for the tide was turning.

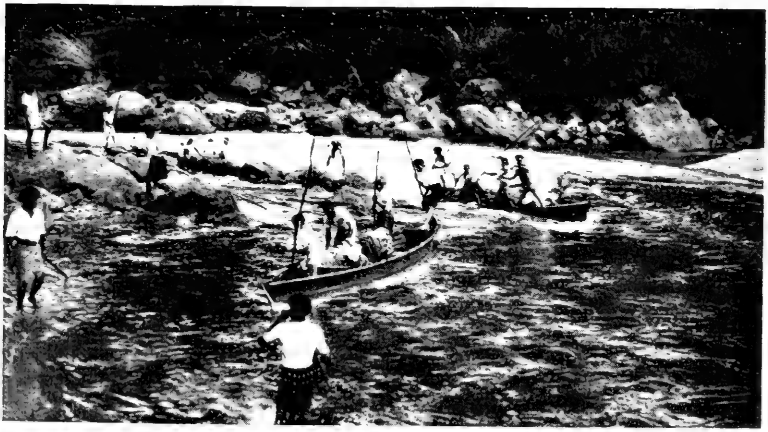
This delightful trip was but an introduction to an eight-day excursion inland first by poling up the Navua and walking across the divide to the Waindina, then by boat down the Rewa and back to Suva. Elsewhere in the volume Doctor Wylie, the botanist of the party, has described this delightful trip into the heart of

Vitilevu, hence I will confine my remarks to some notes of a geological nature. First of all, however, I wish to acknowledge my indebtedness to Colonial Secretary Fell who accompanied us on the trip. By careful planning and excellent organization every detail was so well thought out beforehand that the trip was a pleasure jaunt rather than one of almost insurmountable difficulties; guides, porters, polers for the boats, cooks, interpreter, and even a private secretary made up a large retinue. A royal party could not have been more welcome than we as we were met with ceremony, feasted, and entertained in one Fijian village after another. Mr. Fell managed the whole journey without a hitch; he was very popular with the natives, highly respected by the bulis or chiefs and a jolly good fellow at all times. He has our everlasting gratitude and good will.

The Navua river drains a fairly large territory. Its lower reaches are wide and affected by the tides for some distance and the land on either side is a very fertile delta plain. As the landward edge of the plain is reached, the valley narrows perceptibly, the gradient of the stream increases, and rapids are frequent. In places the valley walls are steep and rocky, almost perpendicular at times. There is little or no valley flat except a few square rods at the turns. Over the steep, tree-fern covered slopes small tributaries come tumbling in, some as silver threads of water, others with great turbulence. At a point some sixty or eighty feet above tide, as accurately as we could estimate by the aneroid, the gorge is quite narrow with sides and floor of solid rock. There is no doubt but that a well constructed dam here would impound considerable water and that a hydro-electric plant capable of generating much power could be built. Our visit was made during the dry season and yet the volume of the stream was sufficient for a considerable amount of power. High water marks on the sides of the valley gave indication that during floods immense volumes pour down the gorge with great violence. This fact, of course, is the one to be most carefully considered in planning a dam. But by making it extra heavy and of good material there should be no difficulty. Records covering stream discharge and flood measurements are doubtless available. If not it would be a wise policy to acquire such data on each stream which is a potential source of hydro-electric energy—and there doubtless are several in a region where the annual rainfall is so great. The rock at this

View of Suva Harbor from Hospital Hill (See page 157)
A sharp turn in a passage in the Rewa delta (See page 163)
The rugged sky-line of Ovalau, Levuka in the foreground (See page 164)
(Photos by Thomas)

PLATE XXVIII



The gorge of the Navua River (See page 160)
A narrow part of the gorge of the Navua River (See page 160)
Poling up the rapids of the Navua River (See page 160) (Photos by Thomas)

place is igneous, some of it basaltic, and some of it is a coarse, angular agglomerate. In places enormous blocks, handled in flood time, lie in the bed of the stream. It is hoped that this source of energy will soon be harnessed for we can think of no greater boon to Suva than cheap hydro-electric power. The distance of its transmission from the Navua gorge to Suva is not over twenty-five or thirty miles.

Namuamua, on the right bank of the Navua, is a very pretty village. During our stay here I made an interesting side-trip up a tributary of the Navua to a place where native informers declared they had found showings of coal, and in fact they had some pieces of carbonaceous shale which burned with some difficulty in the charcoal fire at Goko's cook house. The deposit was finally reached and proved to be a clayey sandstone alternating with thin bands and lenses of shale. The whole was much jointed and where exposed, weathered rapidly along the joints into a crumbly clay. In these ledges, of which ten to fifteen feet are exposed along the stream, are bits of carboncaeous material from a fraction of an inch to an inch or more in diameter. They appear to be inclusions washed in from some earlier deposit at the time the shale and sandstone were laid down. There was nothing to indicate a coal deposit of any value either here or in the original beds whence the carbonaceous shale originated.

On the Wainukovo, a small tributary from the left into the Navua, below Namuamua, is an over-hanging bluff two to three hundred feet high. We found yellowish, sedimentary rocks, largely calcareous, with some sandy and clayey strata interspersed. The beds dip up the Navua, at an angle of 20° or more. The lower part of the section is a conglomeration of volcanic ejecta, rolled pebbles, and other debris. The most interesting feature is the presence of worn coral heads in the talus at the foot of the cliff and in relief over its face. Their precise age has not been determined but they have a story to reveal.

The journey up the Navua beyond this point was on foot. The country grew more rugged and the trail, doubtless as old as the Roman roads of Britain, led by the easiest yet steep grades to the head-waters of the stream, among towering mountains hard by the Korombasambasanga range. The trail finally enters the Navuni-ivi or Namosi gorge at a certain point in which is a low col where grows Seemann's orange tree. Trickling down the grade behind us are the very head-waters of the mighty Navua and before us down the opposite and steeper slope run similar waters to the Waindina. The gorge widens and as we proceed its sides tower higher and higher. In places the narrow flats along the stream are cultivated but if not, an almost impenetrable bush knotted together by mile-a-minute and other vines extends to the very edge of the path. At the divide (650 feet above tide), the gorge runs east and west. Farther on and some one hundred feet lower, the gorge heads to the northwest. Its flat is now wider and the stream several yards in width is confined to one side of the valley; finally, nestled along the right bank, lies the beautiful, thatch-roofed village of Namosi. Turning about at the foot of the rara or village green we viewed the magnificent setting of the Namosi gorge. Back at the elbow where it turns from due west to northwest stand two prominent peaks, sentries of the valley. They are known as the ''Gates of Namosi.'' The cliffs of the valley wall are from one thousand to twelve hundred or even fifteen hundred feet high. Some of their faces are sheer or overhanging. Rarely are they barren of vegetation and where they appear so, the binoculars reveal patches of lichens or other growth. Here and there the cliffs are notched at right angles to the valley and down many a notch comes a wild turbulent tributary. One of the internotch masses rises almost vertically on three sides; on the main valley side it is vertical quite from the base—like some titanic office building. This rectangular towering mass is fully eight hundred to one thousand feet high. It is on the right hand side looking up stream and about a fourth of a mile beyond the buli's house. I named this conspicuous eminence Mount Fell in honor of our kindly host and it is hoped that new maps of Fiji will adopt the name.

The left side of the gorge is, on the whole, less abrupt at the base but it terminates upward in even higher peaks culminating in Mount Namosi whose summit is a little over 3000 feet above tide and fully 2500 feet above the village at its foot. Its summit, like that of the peaks of the Korombasambasanga range to the south, was much of the time swathed in clouds and mist. The rock in the valley and in the cliffs, as near as could be ascertained in the brief time of our stay, is of volcanic origin and is dark in color when fresh. Much of it is made up of rounded cobbles in a matrix of basaltic lava. Some of the pieces are quite crystalline, even dioritic. The cobbles in the agglomerate are grayer, a few of them darker, than the matrix.

The origin of this Fijian Yosemite is a matter of speculation. Erosion has had a part but the small size of the streams and the low col precludes this mode of origin. That the valley is con structional and the result of the down faulting of a narrow block or graben is the most likely explanation as the steep sheer faces of the valley wall at Mt. Fell and elsewhere strongly suggest.

Although Fiji has no evidences of recent vulcanism the great quantity of rock of this origin in the interior points to much volcanic activity at a former time. That there is still smoldering heat beneath is proved by the fact that there are hot springs just above Namosi while near Delailasakau some miles below Namosi we visited a hot spring issuing from a parti-colored, vesicular rock. The water is clear and too hot for the hand. The flow is strong and there is odor of sulphur dioxide. Mr. Fell said that earthquakes of very small tremor occur but rarely in Fiji.

Upon my first arrival in Suva I expressed to Mr. Fell the hope that I might see by way of contrast a part of the north shore where the rainfall is considerably less than half that of the southeast part of the island. With customary generosity Mr. Fell took up the matter and by use of the telephone and written correspondence had the whole trip carefully planned for us in fullest detail. So, on the second day after our return from the Namosi trip, Mr. Glock and myself took passage aboard a little steamer, the Andi Keva. This is a coastwise boat of 106 tons and was the only mode of inter-island communication at the time. In order to negotiate the passes of the Rewa delta at flood tide it was necessary to board the boat at 5:45 A. M. There was a drizzling rain and it was pitch dark as Glock and I stumbled through the narrow streets leading to the wharf. In spite of all we had read and heard about procrastination and slow-going in the tropics it was well for us that we were on time for she put off quite promptly. Her skipper was a fine appearing, business-like man of rather unusual type—a half-caste Fijian. With him were his two robust children whose mother was a Samoan. They were pale-faced, straight-haired, and quite comely.

The voyage was pleasant, the sea being fairly smooth as we were inside the barrier reef the whole way. The delta of the Rewa river is a large fertile area just above high tide. Parts of it are covered by impenetrable mangrove swamps. The Rewa has many mouths or distributaries and it is the custom of navigators of small craft to enter one of these and by zig-zagging back and forth save many miles beside avoiding the more open sea between Nukulau and Makuluva. Our route was through the Wainibokasa passage which turned so sharply at times that a Fijian boatman dove from the prow with a three-inch rope in his teeth and upon gaining the bank on the inside curve fastened the rope to a post set for the purpose, thus turning the boat in her own length. Any slight accident or grounding of the boat long enough for the tide to go out would have meant a long delay. A night in that mangrove swamp with its millions of hungry mosquitoes would not have been a pleasant experience.

Our first stop was at Levuka on the island of Ovalau. This we reached early in the afternoon and we were told that general business routine and tide conditions would keep us there until the next morning. Levuka is the old capital of the Fiji group and is beautifully situated along a shelving shore at the foot of high rugged hills. In spite of its lost prestige it is still a town of considerable commercial importance. We noted several large steamers at anchor loading copra and other produce.

Ovalau is a mountainous island with peaks rising fully two thousand feet. Its deep, short and sheltered valleys are well adapted for coconut plantations and the island is comparatively free from the insects and blights which injure the trees on Viti-levu. The rock observed here is a very coarse conglomerate which in places is rudely bedded and even cross-bedded. A resident told us that the stone is the same on the highest hills of the interior.

The shore of this island for some distance to the north of Levuka shows unmistakable evidence of rather recent elevation. The shoreline previous to the uplift was a bold cliff into which the waves had cut a platform which is overhung at the promontories by hard, conglomerate cliffs. This platform is now five or six feet above high tide and is the site of a level, well-kept road. At low tide hundreds of dead coral masses are exposed near shore. These are much worn and partly dissolved, and when a mass becomes free it is soon ground to pieces by the action of the waves. These coral evidently formed a part of the fringing reef before the uplift. The present barrier reef is miles out. At one point there is a large stack with a big sea cave on its sea-ward side. It is now quite out of the reach of the waves.

The next day found us approaching the northeast coast of Viti-levu. Beyond Tova Peak the vegetation clearly shows the effect of diminished rainfall. It is brown in color, scrubby, and there are very few trees of any size. Before reaching Ellington, our landing place, several small islands appear on the right. One of these, we were told, is owned by a German who vowed when the war broke out not to have his hair cut until Germany won the war. He finally had it cut in 1920. His island is remarkable for the large grove of Casuarines growing upon it. Ellington is merely the deep water entry for Penang which was our objective. Here we were met by a constabulary officer, Mr. S. F. Sanders, who has charge of the police force of the Ra province.

At Ellington we found a representative of the Department of Agriculture busily engaged in exterminating a thistle-like plant (*Xanthium strumarium*) which had gained a foothold from some Australian cargo. It was spreading with alarming rapidity and threatening to choke out native crops and grasses.

In the mangrove swamps near this place is a species of strange fish locally called the gobi or tiloko. It is about six inches in length, its eyes protrude like those of a crab, and its pectoral fins are so modified that it can cling with them to sticks and stones. It passes over the water with a series of hops and skips and refuses unless cornered to disappear into the deeper parts of a pool. After desperate efforts to catch one a shilling was offered a native woman if she got us a dozen upon our return later in the week. Upon the return the fish were presented us in a closed pail and we repaired to a room in which were a table and some chairs to transfer our gobi to a jar of preservative. The lid was no sooner lifted than out jumped most of them and they had to be chased about and caught like so many grasshoppers. The reader can imagine our surprise at the activity and elusiveness of animals which are normally helpless on the land.

Penang is reached by a narrow gauge, two-foot railway owned and operated by the Penang Sugar Company of Melbourne. It seems to be entirely independent of the Colonial Sugar Refining Company which owns and controls the great mills at Lautoka and Nausori. The Penang plant is equipped with up-to-date machinery but the low price of sugar in 1922 compelled it to operate at a very low margin if not at an actual loss.

Our destination in Penang was the beautiful home of Mr. A. E. Bailey, the District Commissioner of Ra. This gentleman and his estimable wife welcomed us most heartily and looked after our every comfort and need. Early next morning riding horses were at the gate and Mr. Sanders of the Police force accompanied us on a long ride to the Rakiraki range which marks a sort of boundary between the wet and dry sections of this part of Fiji. The top of the range is green and forest clad; intermittently great banks of clouds hovered over its top but dissipated very soon if they started down the valleys in our direction. It had not rained in the Ra district for some time. However, this was the dry season and when the wet season comes there is enough for a good sugar crop of high quality. The mode of cultivation, rattooning, and so on are very different from that on the Rewa or Navua deltas where rainfall is very high.

As we ascended into the foothills the lava origin of the range became apparent; the rimrock made a bold scarp. Such a place is Suicide Rock whose vertical, columnar wall of reddish color is several hundred feet high. Suddenly, as the rain forest was reached, there was a change in the vegetation. The wood became dense and damp and the trees closed overhead.

At the top of the range we looked back to the broad Penang valley with its regularly laid out canefields. Beyond the range was a greener region with dense bush crowding in on the small cultivated areas. Nowhere had we ever seen such a contrast in the space of a few miles.

After riding back to a certain point in the range we dismounted and turned over our ponies to a prison trusty who had been carrying our lunch. He took them down the hill to the Fijian village a mile and a half away, while we struck off through the bush to see some old tribal boundaries in the form of a cairn on the hill. From this point we started down a steep valley at the end of which we could plainly see our mounts by the aid of our field glasses. It was early afternoon.

We dropped down a steep slope into tall grass at its foot. The grass was harsh and half dead, cutting our hands and faces at every move. Moreover, it was completely entwined by a slender but tough vine called voivoi. Progress was next to impossible; go back we could not, the slope was too steep. By the use of a pocket knife to cut the vines we made about fifty yards in a half hour. It was hot, the grass was over our heads, we became separated, but kept in touch by shouting at intervals. After another hour or so we gained the bed of the stream where we slipped, crawled and fell by turns. The water was cool and refreshing. Farther down the pools became too deep and we had to detour through the bush again and again. It was getting late, we had visions of spending the night insufficiently clothed among swarms of mosquitoes. Our impatient horses were only a half mile away. Finally the stream widened; we saw a taro patch and beyond it a cow paddock. Soaking wet with perspiration, footsore, and with hands bleeding, we climbed our mounts and galloped on. We had a new idea of the bush and were quite convinced that the dry side of the island is not barren by any means.

Mr. Sanders told us that this grass and bush is the home of droves of wild pig. They are the descendants of some pigs freed on the island by Captain Cook over one hundred years ago. The natives, and occasionally the Europeans, organize hunting parties and an exciting time is had with dogs and guns. There are no large wild animals in Fiji and it is thought that the introduction of the pig as a substitute for human flesh had much to do with the suppression and elimination of cannibalism.

In the Penang valley are several mounds of considerable size, usually of a reddish color. They are evidently much weathered small volcanic cones. The soil on one of them is unusually red. The Fijians' love of a good story explains its origin. It seems that an old chief once upon a time had two indolent sons who killed a favorite rooster of their father's that his early crowing might not disturb their sleep. His blood stains the hill to this day. In order to escape the father's wrath they put to sea in a hastily constructed boat which had a very tall mast. A storm overturned the boat and the long mast fell across the Rakiraki range for could we not see the dent made by it just above Suicide Rock where the spirits of the brothers haunt the place nightly? The natives give this spot a wide berth.

In pursuit of the investigations in Fiji several persons rendered aid in one way or another. Mention has been made of the generous and efficient help of Colonial Secretary Mr. Fell and his official staff without which little could have been done beyond the immediate environs of Suva.

Mr. C. H. Wright, government chemist, gave us a much needed and convenient room in his laboratory for storing and packing. He also loaned books and maps and accompanied us on a very

instructive trip to Colo-i-Suva. Mr. Wright is well informed on Fijian natural history and he speaks Fijian fluently.

The District Commissioners, Mr. Stewart of Rewa, Mr. Bailey of Ra, and Mr. Disbrowe of Navua, rendered every assistance in their power. None of us will forget the hospitality with which we were received at the homes of each of these gentlemen. Mr. S. F. Sanders of the Wailaka constabulary presented us with several rare Fijian curios and with some interesting moonstones from near Vitilevu bay in Ra. He was our companionable guide to the Rakiraki range. Mr. Sturt, of the firm of Sturt, Ogilvie and Company, Suva, gave me several beautiful cone and Harpa shells from his fine collection. Mr. Sturt has thousands of perfect Fijian shells which he has acquired of native fishermen during a period of over forty years. Some of them are as rare as they are beautiful. We especially admired, and it is feared, coveted, his magnificent cowries, cones, and Olivas.

Many other individuals rendered aid and volunteered services in many ways. Especially do I wish to extend my gratitude to the officials of the Fiji Club for the many courtesies extended me there. It was with deep regret that we passed Kandavu light house as night closed over the last of the Fijis with our boat headed for New Zealand.

CHAPTER X

A STORMY VOYAGE TO NEW ZEALAND

After all our good-byes had been said to our Fiji friends on the dock, we went below to inspect our quarters. The Makura was considerably smaller than the Niagara, having a displacement of 13,500 tons as against the 20,000 tons of the latter. But the size of a vessel is no measure of her seaworthiness nor of her comfort. In spite of the crowded condition of my stateroom, where I had at least space in which to sleep, this vessel was just as good a sea home as one could ask, and we found nothing at all to complain of in the service.

The run from Suva to Auckland, New Zealand, is a comparatively short one of only 1140 miles and took less than four days. The rest was a welcome interlude between the work in Fiji and that which was still to come in New Zealand.

July 4th was a beautiful clear day and the temperature was balmy, just right for comfort. On deck we found two Americans strutting up and down in a very chesty manner, displaying gorgeous neckties in the shape of American flags. They were full of brag and made themselves decidedly unpopular. An Australian official afterwards informed me confidentially that we were welcome to claim all such men, as they were wanted by no one else. I was mainly concerned about the dishonor they did our beautiful flag and it was largely on that account that our party left them severely alone.

There were several American school teachers in the second cabin going on a vacation trip to New Zealand. They appeared to be a jolly crowd, enjoying the experience hugely and will doubtless have many extraordinary adventures to relate. American women are able to take care of themselves anywhere and are among the most independent travelers the world over. Such trips are the best sort of relaxation and have a rare educational value.

The deck sports were in full blast. People on these long voyages give themselves whole heartedly to the various sports, particularly on British ships. A ''sports committee'' is elected and all sorts of games and tournaments arranged.

In the smoking room Thomas had a heated argument with some Australians who were roundly cursing America on account of prohibition. I suppose they thought it might be catching! It was really amusing to find the colonials so incensed against the United States on account of strictly domestic affairs, such as our prohibition laws.

At dinner that evening the band played "The Star Spangled Banner" in honor of the day and all passengers stood up in recognition. Such international amenities always move me greatly. They make me feel that blood is thicker than water and that old England is really the mother country in spite of all efforts of our hibernian countrymen and others to "twist the Lion's tail!" We responded with hearty good-will when the dinner ended with the strains of "God Save the King." I could not help thinking of how great the geographical distribution of my July Fourths had been for the preceeding five years,—1917, Barbados; 1918, Antigua; 1919, in the hospital at Rochester, Minn.; 1920, in camp in Montana; 1921, at home in Iowa City and 1922 in the South Pacific en route to New Zealand.

In the evening we had a lecture by Professor Chant of the University of Toronto who was leading a party to a remote spot on the northwest coast of Australia for the purpose of observing a transit of Venus due sometime in September. What struck me most forcibly was the very generous support given by the Australian Government to this scientific expedition. It had volunteered to meet all the expenses of the entire party from the time it landed at Sydney and during the journey of some thousands of miles to and from their remote station on the northwest coast. Not only was free transportation of the party and its bulky equipment furnished, but quarters and commissary supplies during the entire time spent in Australia, which would be some three months as I understood it.

The next morning the ocean was a little rough and some of our party were again afflicted with *mal de mer.* There was a slight following sea, a northerly wind and occasional rain squalls which sent us below. I had a talk with Captain Wills about the war and he finally expressed his feeling and that of his fellow countrymen about the late entrance of the United States into the world conflict, although he showed no bitterness.

The wind rose during the next night. By breakfast time on July 6 the sea was quite rough and a good many passengers were seasick. The wind increased rapidly, the sea grew heavier during the day until the gale amounted to a storm, and huge waves larger than I have seen for many years rolled in from the Antarctic. The Makura shipped masses of foam but no green seas until nearly noon, then they smashed against the vessel with solid blows like a sledge-hammer, making her shiver and reel like a drunken man. Seated in a big wicker chair in the smoking room I was trying to write when I was suddenly tipped over and rolled on the floor, after which safety was secured by seeking a corner on a divan which could not capsize. It was hard to keep on writing with one's attention being continually distracted by the angry seas outside. The ocean when enraged has always had a real fascination for me, and at such times there is a sort of exultation that repeated experiences do not lessen as the years go by.

I had a long talk with a gentleman who had lived forty years in Fiji and owns a large shop there. He expressed a sincere admiration, indeed affection, for the Fijians; but does not want too many white men to locate there as he says they will "spoil the natives." Possibly he enjoys a business monopoly.

After lunch the storm increased in severity, and two men were hurt, one a passenger and the other a smoking-room steward. Both had nasty falls. The steward suffered from a badly cut head when he was thrown violently against the table. It was really dangerous to try to move about anywhere. At lunch there was a tremendous crash of tableware as a sudden, dizzy lurch of the ship emptied all of the tables and broke hundreds of dishes. Then an extra heavy sea struck the ship a solid blow on the bows, broke through the heavy bulwarks on the port side, smashing the iron plates, surging over the smoking room and lounge on the upper deck, breaking some of the strong storm shutters and flooding the room with its upholserted furniture. The Captain declared that this was the heaviest storm the Makura had encountered for eight years or more, but she was sea-worthy and there was no real danger although the vessel was delayed six or eight hours by having to slow down. There was a massiveness, a sheer bulk and thrust of these huge waves of the South Pacific that I have never seen surpassed, although it seems to me that I have seen higher seas in the Atlantic. We regretted that no photographs could be taken as the lens was immediately covered with a fine mist of spume that drifted continuously across even the highest deck.

Although we were in no serious danger, the continuous and violent motion was exceedingly tiresome even to those who were not seasick and we soon had enough of it.

In the evening the "survivors," meaning those not down with seasickness, had an enjoyable time around the piano in the lounge. The Britisher enjoys singing and the Colonials on the Makura were no exception. Some of them were first-class vocalists and there was a good accompanist at the piano. I was surprised at the number of old time American favorites which seemed familiar to them—"Suwanee River," "My Old Kentucky Home," "John Brown's Body," "We Are Tenting Tonight on the Old Camp Ground," "The Vacant Chair," "Dixie," "Hail, Columbia," and a lot of others. We really had a jolly time, although it was hard to keep on our feet, as the vessel reeled her way over and between the big seas.

By daylight we sighted some of the out-lying islands of North New Zealand, more or less in the lee of the land. By noon we were in the great Hauraki Gulf which deeply penetrates and almost bisects the North Island of New Zealand, and ends in the beautiful landlocked harbor of Auckland, with sufficient depth of water to enable the biggest trans-Pacific liners to go up to the extensive series of docks on the sea front of the metropolis of the Dominion of New Zealand.

We passed in sight of Great Barrier Island, where the wreck of the "Wiltshire" was breaking up. We heard of this disaster during the voyage. It seems that a captain had in some way lost his bearings during a severe storm and foggy weather and the vessel had been caught in the set of an unexpected current and piled up on the rocky coast of Great Barrier. I afterward secured a good photograph of the wreck which was a frightful one as the big, new "Wiltshire," a fine steel ship, was actually broken in two, the two halves being separated as cleanly as by a cleaver and lying side by side on the rocks. By what seemed little less than a miracle no lives were lost although great difficulty was experienced in getting a line ashore. I was told that one brave fellow jumped into the icy sea which raged around the stricken ship and the ugly rocks of that very rugged coast and succeeded in getting a line ashore through the breakers, a feat that seems impossible to one who has witnessed the fury of these breakers and knows the sheer rocky coast at this place. Others on shore helped him, however, and they fastened the end of the line high up on the front of the cliff and finally succeeded in hauling every man in the Wiltshire to safety. The vessel was a total loss but they were successful in salvaging a large part of the cargo after the sea went down.

Another wreck that I afterwards saw in dry-docks was one of the strangest of the "stranger than fiction" tales of the sea. The ship was the "Rona," a steel cargo vessel loaded mainly with sugar. On a perfectly clear evening, with no sea running and all the shore lights burning brightly, this ship ran square into a small rock on which stands a light-house with a powerful light. It seems as if there had been a deliberate attempt to ram the light-house itself, for the bows of the "Rona" were pointed directly at it and actually reached to within about forty feet of the light itself.

In the Court of Inquiry which afterwards investigated the cause of this wreck the first mate, a man with an excellent record and a Master's certificate, testified to the following effect: "The ship was on her true course when the Captain went below to attend to some business leaving the vessel in my charge with orders to 'steer for the light'—and I did!" Surely a most successful piece of navigation, for he struck it fairly as to the direction and would have run it down had not the intervening rock interfered. The first officer claimed that he was merely obeying orders, but further explained that he was deceived as to the distance of the light and did not really intend to ram it.

Although it was a brilliant sunny day we found it quite cold on deck and we realized that we had gone through the tropics into the winter climate of the South Temperate Zone. Auckland is about 37° South and we were consequently within about 5° of being as far south of the line as we were north of it when at home in Iowa. It was actually mid-winter in New Zealand.

The run up the Gulf to Auckland was delightful and the scenery all that glowing accounts have pictured it. The sea and sky were intensely blue, the islands we passed were very rocky but many of them green with their non-deciduous trees and shrubs, and the mountains loomed on the distant mainland. Sailing boats and steamers were numerous and the suburbs of the city looked like summer resorts at home.

As we neared the harbor all passengers were summoned for medical inspection which was different from any we had previously experienced. We were formed in line on deck with our passports and every one was ordered to bare both arms to the elbow. It was, as I have said, quite cold, and as all had overcoats or heavy wraps it was no easy matter to bare the arms according to orders. So overcoats were taken off, cuffs unbuttoned, and sleeves rolled up to the required extent. When we appeared before the officers who were conducting the inspection each of us was told to extend both arms straight up. The official gripped them with a quick pressure below the elbows, passed the hands toward the wrists and told us to pass on; that was all there was to the inspection. I could not help admiring the excellent memory of the chief steward who called out the name of each passenger as he confronted the officer, giving it without hesitation and correctly in every case.

I afterwards learned that this curious form of inspection was due to a report of a few cases of bubonic plague in Australia, and that its presence in an incipient form could be detected by this procedure.

The inner harbor of Auckland presents a busy scene with numerous ferry-boats plying back and forth to various points on the bay, Devonport, Birkenhead and other suburbs. The docks are quite extensive and big steamers from many points of the world showed their painted funnels and masts above the great ware-houses. An extensive railway terminus with numerous small engines and cars very much after the English type could be seen. Beyond this the city had a metropolitan aspect and its numerous rounded hills were crowned with imposing structures and parks. After our stay in Fiji the whole scene was distinctly impressive.

But the business of disembarkation soon took our attention and all was excitement and confusion. The stewards who had served us had been remembered with the usual tips and the stateroom boys were taking our luggage ashore to the custom-house on the wharf to which the Makura was soon tied. Some of our party had a distinct grudge against the good ship Makura on account of her antics during the storm, a thing for which it was unfair to blame the vessel which had behaved as well as could be expected, considering the pounding she had sustained.

Our passports were taken up and we were instructed to register with the police within seven days of our arrival, at which time our passports would be returned.

The laws regarding immigration are very strict. No Germans or Russians were allowed at that time to land at any point in

New Zealand, and very severe restrictions were imposed on all Orientals. Perhaps this is the reason why the Dominion of New Zealand claims the purest Anglo-Saxon population in the world. It is a rare thing to meet any but English, Welsh, Scotch, or a very few Irish in that country and practically all of the Colonials are descended directly from citizens of some part of Great Britain.

We were met on the dock by the manager of the Government Tourist Bureau for Auckland, Mr. Wallnutt, who at once took us in charge in the most helpful manner possible, saying that he was instructed to see all of our baggage and equipment through the customs without delay. Not a thing was opened after I had explained that we had nothing but personal effects and the necessary scientific equipment for such a trip as ours.

This Government Tourist Bureau, by the way, is one of the best organizations we met with in New Zealand. It welcomes the stranger on the dock and is at his service throughout his stay in the Dominion. It arranged all of our travel, secured our tickets and wired for our hotel accommodations wherever we went. Nothing could give a more pleasing impression to travelers from other lands than such service. It saved us without charge much time and annoying perplexities wherever we went. I believe that as Americans learn of the superb attractions of New Zealand the tourist trade will become much more extensive than it is at present and that the service of this Government Bureau will make travel more and more popular with Americans.

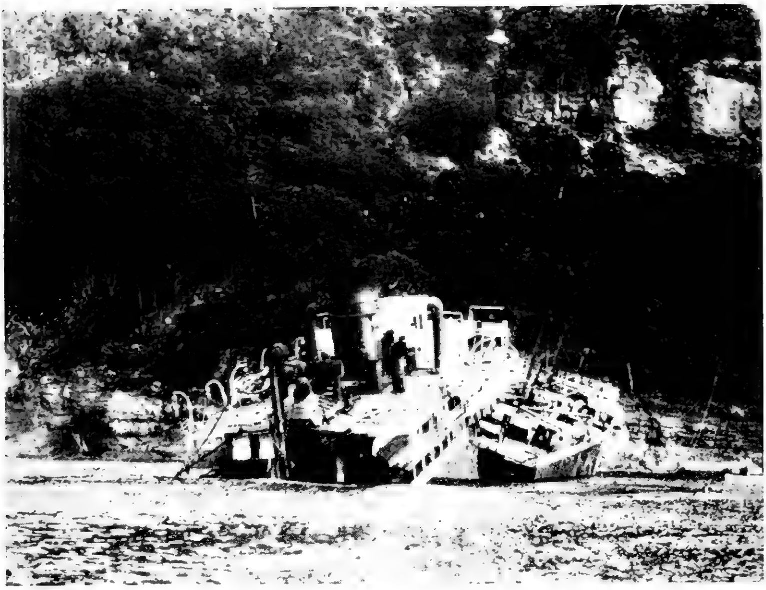
Mr. Clement Wragge, a well known meteorologist came to the wharf to welcome our party in the name of the scientists of New Zealand and, at my request, secured lodgings for us in Auckland. Mr. Wragge was an eccentric character with a great reputation as a weather forecaster, a reputation extending far beyond New Zealand. We had heard of him at Fiji and were assured that the planters there relied implicitly on his prognostications and that these forecasts were very generally correct. He told me that the matter of predicting the weather was a much easier and simpler problem near the Antarctic regions than in the Northern Hemisphere; I have no doubt that his long experience and scientific training enabled him to attain a very creditable degree of accuracy. Since coming home we have received news of Mr. Wragge's death, which was not entirely unexpected, as he was quite an old man when we saw him, although active and alert in manner.

Our luggage was piled on to a big lorry, and we were placed in taxis and quickly taken to our quarters at No. 4 Emily Place, which is near the wharves, railroad, the Auckland museum, and the main business thoroughfare, Queen Street. There we found ourselves conveniently situated but we suffered severely from the cold. The rooms were entirely unheated even in mid-winter and although we dressed in thick winter clothing we were never really comfortable in the evening until we were in bed.

Of course this is the custom of the country and indeed of almost all British possessions as well as of England itself. Perhaps we suffered more on account of coming directly from Fiji where it is always warm. We managed to keep fairly comfortable while at work during the day and in bright weather the temperature was not uncomfortable outside.

Steamer day at Suva (See page 169)
Part of the Auckland docks (See page 174) (Photo by Wylie)

PLATE XXX



The wreck of the "Rona" (See page 173)
The wreck of the "Wiltshire" (See page 172)
(Photos reproduced by permission of W. Beattie, Auckland)

CHAPTER XI

AUCKLAND AND VICINITY

Emily Place is on a rounded knob of a hill overlooking the harbor and railroad terminus. Beyond the water with its numerous vessels of all descriptions one sees the large suburb of Devonport and still further the extinct volcano of Rangitoto rears its head, the highest mountain in that general region. The plan of the city is irregular to a perplexing degree, due largely to the number of rounded hills of volcanic origin which break the contour of the plain over which the city is spread. The streets, of course, seek the lower levels and wind around the bases of these hills in the most erratic way. The Post Office and many of the finest business blocks are on Queen Street which runs along an irregular depression or valley with higher ground on either hand. There are some fine parks and numerous churches, some of considerable architectural pretension. Electric tram-cars furnish good transportation facilities and there are also numerous public taxicabs.

The general tone of the city is metropolitan as might be expected of the metropolis of the Dominion of New Zealand, with a population of about 158,000. It has the stir and general air of a much larger place and is the port of entry for trans-Pacific steamers from America, Australia, Fiji, Polynesia in general, South Africa and India. One line runs directly to England by way of Panama. This is, therefore, a city of considerable commercial importance. The climate is milder than that of South Island, and many subtropical plants are found in its parks and gardens.

The restaurants furnish very good substantial meals at a cost of about 36 cents in our money and living is somewhat cheaper than with us, but one has to be on hand promptly at meal time or he finds the places closed. There are few places where one can be served at any hour of the day and still fewer are open at night. Even if the visitor is on hand during the prescribed hours he may, if somewhat late, find that most of the dishes on the menu are out and must content himself with what happens to be left. There is always an excellent fish course, usually in the shape of snapper, probably the best table fish to be had in New Zealand. The famous New Zealand mutton is the standard meat, although beef is often served. Vegetables, coffee and a "sweet" for dessert complete the bill-of-fare. At all of the better restaurants which we visited a regular dinner was served in the evening at the price mentioned and, although there was some choice, there was nothing like the variety of foods which appear on the menu of our middle-class restaurants. But the meals are good enough for any reasonable person and remarkably cheap. The larger hotels charge much more for meals which are somewhat more elaborate. Tipping seems to be unknown in restaurants.

The stores or shops in the principal business streets are large and about as pretentious as are found in cities of similar size in the United States.

A map of Auckland shows it to be about four miles square and the maze of streets, especially in the business district, makes one fairly dizzy, being more perplexing, if possible, than the old part of Boston. However, we soon got our bearings and learned the principal landmarks.

The main attractions from the visitor's standpoint are the parks, libraries, art galleries and museums, most of which will be mentioned in the course of this narrative.

As it was winter, my own special work, marine invertebrates, did not offer much that was alluring for it was too chilly to do shore collecting. Therefore, it seemed best to devote most of my time to establishing connections with the scientific men and learn what I could from the museums and libraries. I also hoped to accomplish something worth while in the way of exchanging specimens and publications, thus making the visit profitable from the University's standpoint; I feel that these hopes have been fairly well realized. But it took considerable time to gain the support of the Dominion Government and little was accomplished along this line before we went to Wellington, the capital.

On the first morning after arrival I proceeded to buy some warmer clothes and finally fortified myself against the cold by wearing a suit of winter underwear, an extra undershirt of New Zealand wool, a good woolen sweater and a suit of ordinary winter clothes; and in addition I usually wore a rain coat. Even then I was always chilly in the evenings. Clothing proved to be just about as expensive as at home, but the quality perhaps averaged better.

On Saturday there was nothing doing in the afternoon, as every business place was closed up here as elsewhere in the Dominion. We therefore elected to take a half-holiday and attend a foot-ball game. We found the tram-cars crowded, likewise the ball park in the suburbs. The game was Rugby, of course, and the grammar school and King's college were the contestants. The boys appeared a little older on the average than our high school lads. They wore no guards, pads or extra protection of any sort and the knees and a good deal of their legs were bare. There were no chalk-lines forming the familiar gridiron of our fields and the object was to kick rather than to carry the ball. There were fifteen men on a side and the game was very snappy and quick. No time was taken out and there was a continuous series of bewildering fast plays throughout each quarter. When the ball went over the side lines it was at once thrown back into the scrimmage and the "scrim" was formed by a circling mass of boys who milled around until the ball was forced out of the ring and into play.

We had a great time getting back to town as the tram service was quite inadequate to transport the crowd; the laws regarding over-crowding were strictly enforced, no more passengers being admitted than there were seats, and it seems that strap-hanging is an unknown art there. The guard stood at the entrance and counted the people as they got aboard and immediately barred the door when the quota was complete. Several times we were just too late and waited for over an hour before finally finding seats. The fares are paid according to a zoning system and one pays in proportion to the distance, being given a receipt by the conductor.

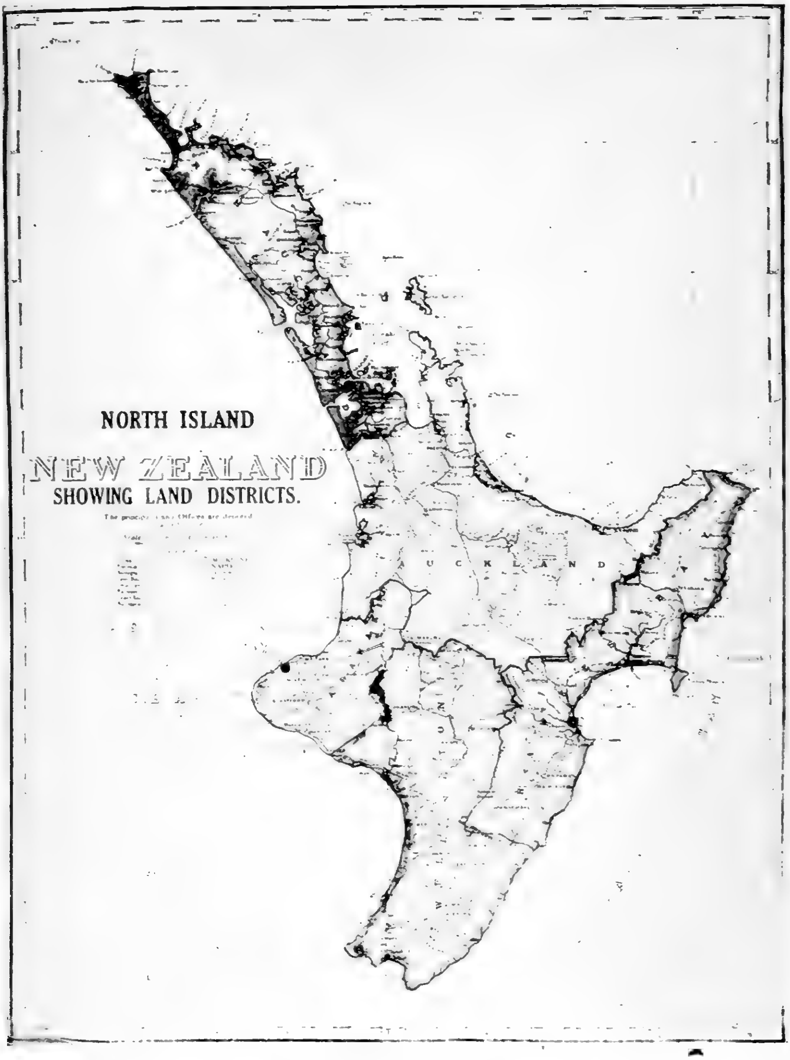
We got back to our restaurant almost too late to be served and most of the articles on the bill of fare were out, so that we had to content ourselves with cold mutton, bread and butter. A little later and we would have gone supperless to bed.

Sunday was a bright sunny day, but chilly inside; so Thomas and I sat on a bench in the little park at Emily Place. Here we saw the ubiquitous English sparrow again, the little rascal that is rapidly populating the world, and is almost exactly on the opposite side of the earth from its original home. A man strolled toward us and taking a seat beside us immediately began a fierce diatribe against the United States on account of prohibition. He declared that our people were crazy and that taking away the poor man's beer would cause a revolution. Thomas tried to reason with him but he became more and more violent until my worthy colleague became disgusted and walked away. I calmed the man down and we talked of other things. Prohibition we found a matter of intense and often bitter discussion in New Zealand where a prohibition party had developed considerable strength.

We then went to the Presbyterian church, a building quite classical in its architecture, but found its interior colder than any other place we had been in, in spite of our extra heavy clothes. The people were cold too, notwithstanding that they have long been accustomed to heatless houses, public and private, and they were coughing and snuffling more than any American audience we had seen. I was not surprised to learn later than pneumonia was common and the mortality from that disease alarming in New Zealand. The sermon was given by a Scotch clergyman and was almost as cold as the church. No one spoke to us either before or after the services. This was our last attempt to attend church during our stay in New Zealand.

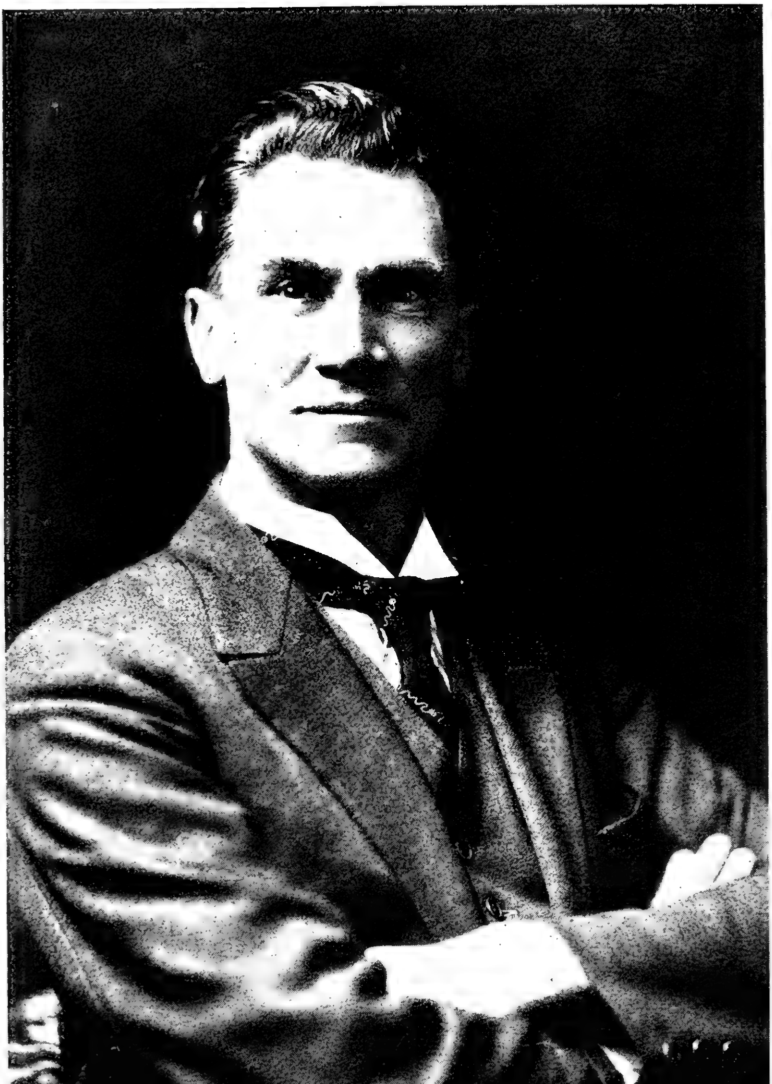
Sunday is very strictly observed and no places of business are open except a limited number of restaurants; not even cigar stores, news stands or soda water places were open, and the railroad trains do not run on that day with the exception of a few to the suburbs. Ferry boats and excursion steamers ply across and about the harbor, but no places of amusement are available; even the motion picture theatres are closed on Sunday and Sunday evening.

That night some of us attended a lecture by Clement Wragge who welcomed us to New Zealand. He gave a somewhat rambling talk on meteorology and his experiences in various parts of the world, using lantern slides for illustrations. The proceedings were opened with prayer and a hymn which gave them the necessary religious tone to meet the requirements of the law, as I understand it. He advertised several of his books and a sort of experimental garden which he had established at Birkenhead across the bay where he presided over the "Wragge Institute." Here he seems to have demonstrated the practicability of raising tropical plants such as bananas and even palms in the climate of northern New Zealand. He charged admission to his Sunday evening lectures and hoped thereby to raise funds for a wireless station for his meteorological work.



Map of North Island, New Zealand

PLATE XXXII



Mr. J. Hislop, Undersecretary of Internal Affairs, New Zealand A powerful and efficient friend of our party

The next morning we went to the Police Station and registered as required by law, and, as none of us had ever been ordered to appear before, the experience was unique. The officers were very courteous and explained that we were doubtless perfectly respectable people and would be subject to no further annoyance. We then went to the Customs House where our passports were returned to us without further formality. Upon drawing twenty pounds on my letter of credit I found that there was a charge of three "bob" (shillings) for exchange.

Returning to the Auckland museum I met the curator, the veteran botanist, Cheeseman, a man of world-wide reputation as a systematist and particularly for his classic work on the flora of New Zealand. He was very courteous indeed, promptly agreed to allow us to use the museum for working headquarters during our stay, and allotted a room in the basement for the storage of our equipment and collections. He also told us to make ourselves at home in the excellent scientific library of the museum where there was a *real fireplace*. There we spent many hours in comfort while consulting the books and scientific periodicals in this extensive library, which is not open to the public and is available for accredited specialists only.

Mr. Cheeseman was apparently a very old man and quite feeble, but he took time to show me through the museum which is one of the best in New Zealand, probably actually the best in the world so far as ethnological material regarding Maoris or natives of New Zealand is concerned. Only a few weeks ago the writer received the news of the death of this veteran and well beloved scientist, who was probably the most distinguished botanist New Zealand has produced.

In the museum are many zoological treasures, such as an excellent habitat group of the kiwi, or *Apteryx,* a wingless bird still rather common in some parts of North Island. But the Maori work, particularly the marvelous carvings in wood was the most interesting part of the exhibit and is exceedingly well installed and displayed. Best of all it has a series of descriptive labels printed in large type and giving more adequate information than I remember having seen in any other museum. The collection is literally priceless and would be creditable in any of the most pretentious museums in the world. There was an entire "guest house" sixty feet long and elaborately carved outside and in, especially on the front, doorway, and interior pillars and posts.

The rafters are painted in very pleasing and graceful designs in red, black and white. Inside, between the upright, richly carved slabs, the walls are covered with finely woven reeds bound together with flax in regular geometric patterns, giving an exceedingly dainty effect.

The finest and most complete Maori war canoe of the ancient kind is here. It is 84 feet long with a beam of 7 feet, and was capable of accommodating one hundred warriors. I counted the seats and found the statement to be true. The prow, and particularly the great sternpost, was the most elaborate piece of perforated carving which I saw in New Zealand, the spiral design predominating. The wood was black and resembled the finest ebony. This canoe and the "guest house" are the largest objects displayed, but there are hundreds, perhaps thousands of others which are smaller but of equal interest. An ethnologist could spend many months there in a delightful and profitable study of the treasures in the Auckland museum, and I am sure he would be impressed with the artistic skill of the Maoris in carving everything, even the bailers for their canoes!

There is a strict law in New Zealand against the exportation of genuine Maori work, but much of it was taken out of the country before this law was passed.

The exhibit of jade or "green-stone" was particularly valuable, as well as interesting. This beautiful stone is hard enough to scratch glass and takes a very fine polish. The work of cutting it without the ordinary metal tools must have been arduous in the extreme. When separating a piece from a large block a groove was formed by rubbing with wet sand under a thin edged stone, and the groove was deepened with almost infinite patience until a slab was cut off. The "mere," a spatulate, short, club-like affair, was made of jade and used by the Maori warriors; and a curious grotesque figure called "Tiki" was carved from a flat piece of jade and worn by the women as a sort of good luck charm.

I was glad to learn that something like $1,000,000 had been appropriated for a new building to house these superb collections. I understand that this is a municipal museum and it is one of which any city might well be proud.

The next day I found myself greatly interested in the beautiful carvings in the museum and went on a search in the various photograph establishments to find what they had in the way of pictures of this work. Our cameras were hardly suited to bring out these delicate designs. After visiting several shops where photographs were on sale, I found a place in the top story of the Victoria Arcade which was just what I wanted. The place was quite unpretentious and not at all advertised, but there was a photographer who was a real artist and had won the "Grand Prix" at the Panama Exhibition. Mr. Henry Winklemann, whose specialty was yachting scenes of unusual excellence, had there gathered together an admirable series of illustrations of Maori art, bringing out the finest details with a fidelity which seemed to me unexcelled. He himself was absent, but had left his pictures in charge of Mr. L. Stubbs who kindly showed them to me and became interested in my plan to procure a series to be used in University publications and for lantern slides. The photographs were all copyrighted but Mr. Stubbs said he would take the responsibility of allowing me to use them for educational purposes, provided due credit was given to Mr. Winklemann. I thus became the possessor of a very good series illustrating Maori houses of various sorts, their native dress and details of their carvings which I could not have obtained in any other way. The series also included pictures of canoes, canoe races and other characteristic activities which will help American audiences to a better understanding of these wonderful people of the Antipodes.

Back again in the museum, I met the assistant curator, Mr. L. T. Griffin, F.R.Z.S., an up-to-date museum man with much experience as a zoological collector in South Africa and elsewhere. He is, moreover, a taxidermist of excellent ability and resource. He said that museum curators in New Zealand were greatly hampered by legal restrictions regarding collecting birds, particularly, and seemed doubtful about our securing a permit for Dr. Stoner, our ornithologist, to obtain representatives of the avifauna of that country. On account of this restriction the Auckland museum had hardly any duplicates available for exchange.

Mr. Griffin is a most versatile man, his main zoological interest being in fishes, and his exhibit series of the fishes of New Zealand is one of the best of its kind. He is also an artist of real ability, illustrating his work with exquisite colored plates, and the fishes in the museum are colored with fidelity to nature.

Many of the Maori carvings bear a close resemblance to the totem poles of the Alaskan Indians. No metal tools were used for this work but sharp shells and stones were utilized. The eyes in the figures are made of the pearly abalone shells with black pupils for centers. Elaborate spiral designs are common and we were told that the idea was derived from the manner of unfolding of circinate fronds of the tree ferns so common in New Zealand. Human figures in these carvings are always represented, so far as I saw, as having but three fingers or toes on each hand or foot. I was unable to find an explanation for this, but heard a suggestion that this was a token of high rank among the old Maori.

These people are said to have emigrated from Rarotonga and Tahiti five or six centuries ago, traveling in the great canoes that have become historic, just as the caravels of Columbus and the Mayflower are famous in our annals. There are some gruesome specimens of the art of preserving human heads by the Maori method of smoke drying, their elaborate tattooing, or rather face carving, and the fact that the lips have shrunk away from the protruding teeth give them a horribly grotesque expression. These heads, by the way, were formerly much in demand as curios, and the accommodating natives readily furnished them to traders, ship captains, etc., which resulted in quite a brisk trade that had to be sternly repressed by law.

At the office of the Union Line S. S. Company, I found that, on the request of Mr. Irons, Vancouver Manager of the Canadian Australasian Royal Mail Line, reservations had been made for our return trip, Wellington to San Francisco, on the "Tahiti" sailing August 15.

On July 13 Stoner, Thomas, Glock and I visited the island of Rangitoto in a fast launch kindly placed at our disposal by Mr. Hamer, the Harbor-Master at Auckland. The early ride through the harbor and out into the gulf was a delightful experience; it was a bright sunny morning, the sky and the sea both were intensely blue.

At about ten we reached Rangitoto, on which is the mountain of the same name, one of the most prominent hills visible from Auckland. The island is entirely volcanic and the mountain itself one of the most recently formed of the volcanic cones in that part of New Zealand. It is quite symmetrical and has a deep crater a little to one side of the summit. There is a good trail made by the voluntary labor of the people who use the island as a summer resort. Anywhere aside from the narrow trail the surface is a mass of jagged, sharp-edged rocks of scoria interrupted often by impenetrable bush. We saw a great profusion of unusually beautiful lichens along the way and also encountered a wallaby, or kangaroo, that allowed us to approach near enough to secure his photograph. From the top of the mountain we had a superb view of the gulf, harbor, adjacent islands and the city of Auckland with its suburbs.

After descending from the mountain we again took to the launch and visited the municipal quarries on another part of the island. These are quite extensive and yield immense quantities of rock for break-waters in the harbor and "metal" for roads. The larger rocks are blasted out, placed on large lighters by heavy cranes and then taken to the break-water. The smaller fragments are run through a crusher near the shore and used in road making.

It was low tide and collecting was good along the rocky shore where numerous pot-holes had been hollowed out of the scoria by the action of the waves. A number of specimens of anemones, mollusks, and starfish were secured.

On the way back we visited the big dry-dock where the "Rona," whose performance in trying to buck into a light-house has already been recorded, was undergoing repair. She was an 8000-ton steel steamer and her fore-foot was crumpled up for a distance of about fifteen feet. She had struck another rock on being hauled off, which resulted in still greater damage to her bottom, below the engines, a bad place to reach in making repairs. We saw the machine shops connected with the dry-dock, where there are large lathes for turning out great guns, rollers for bending steel plates and many other powerful machines; there were pumps for emptying the dry-dock at the rate of 3,000,000 gallons per hour.

The next day I went with a letter of introduction from Mr. Griffin to Mr. Deighton, Manager of the Municipal Council's Fish Market. This is an interesting experiment in municipal ownership, designed to bring down the price of fish, which was said to have been controlled by a private monopoly which maintained higher prices than the city fathers thought justified. I understand that this objective has been achieved.

My object was to find a way to do something along the line of collecting marine invertebrates, my special job, in spite of the winter season. I thought that the captains of the New Zealand trawlers owned by the the Municipal Council's Fish Market might be induced to pick out and save the invertebrate material that came up in the trawls and which would otherwise be dumped over-board. Through the request of Mr. Griffin several specimens had already been saved for me in this way, and Mr. Deighton kindly promised to do what he could to persuade the skippers of the trawling fleet to continue the good work by saving all of the specimens they thought might be of scientific interest. But I succeeded in making still better arrangements for collecting marine material. The trawler Cowan was just in with a load of fish and Mr. Deighton introduced me to her skipper, Captain McKay, with the suggestion that I might go out on a trawling cruise with him. Captain McKay proved to be a man after my own heart, a Scotchman with a delightful burr and as fine a specimen of an honest, keenly intelligent sailor-man as could be found. He extended a cordial invitation to take a cruise with him in the Cowan on his next trip beginning July 20. I had always wanted to add such a cruise to my somewhat varied marine experiences, and gladly accepted; although I knew well enough that life on a trawler in winter would be no child's play, indeed much more like the experience related in Kipling's ''Captains Courageous,'' than the ordinary sea life. As a matter of fact I have always considered deep-sea fishing in winter about as severe a test of endurance as could be imagined. But I believed myself tough enough to stand it, at least for a few days, and was indeed keen to try it.

Calling on Mr. Hamer to thank him for the use of his launch on the Rangitoto trip, I found him absent, but his assistant, who was in, took a very sincere and kindly interest in our plans. He believed that the best place to collect marine specimens was the little island of Rakino further out in the gulf than Rangitoto, and took me over to the office of Mr. Sanford who controls that island. He was absent, but his brother at once interested himself in our project and introduced me to Mr. Allison, chief of the ferry service, quite an extensive organization, by the way. This gentleman very generously offered me the use of his own launch to visit Rakino on Wednesday, July 19, when he believed that there would be a good low tide. So the work sceemed opening up for us at last.

My last pair of shoes brought from home were worn out, the reef work at Makuluva having been the ruin of several pairs. So I proceeded to buy some shoes of New Zealand make, all of which are extraordinarily heavy; the ordinary American styles are regarded as quite a curiosity, indeed I was asked if mine were not made of kid. I bought a highly recommended pair for 32/6 and they proved instruments of exquisite torture, abrading the region of the tendon of Achilles until both ankles were worn raw and bleeding and I was practically a cripple, suffering pain at every step. Mrs. Stoner had some adhesive tape and bandages which helped a good deal but there seemed no hope of real relief. After hobbling around for about a week, however, I succeeded in having my old shoes patched up.

The Museum contains the finest moa material I have seen. Besides a complete restoration of the entire bird made by Mr. Griffin, who used feathers of the apteryx for covering his manikin, there is a very large complete skeleton, and mounted specimens of all the related non-carinate birds including the ostrich, cassowary and emu, to illustrate the gigantic size of the moa as compared with some of the largest existing forms.

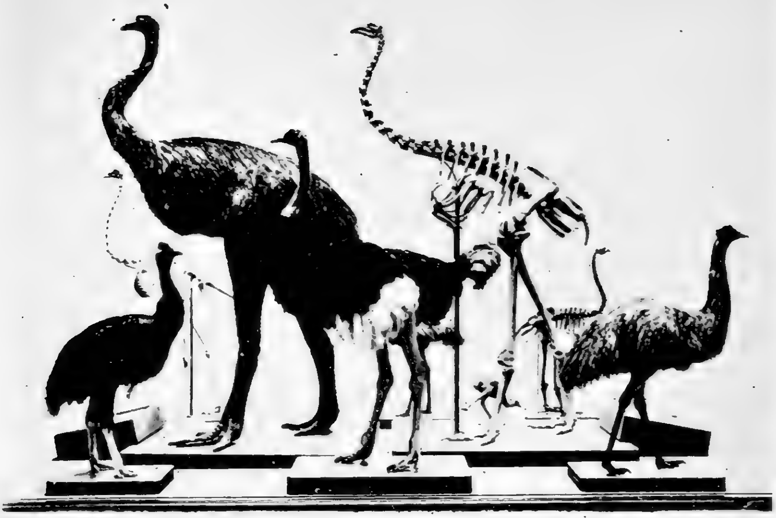
Sunday, July 16, was spent in resting and writing and in photographing some views of Auckland, particularly in the parks. Later I had a very interesting talk in the museum library with a Mr. Holder who had spent a good many years in the Solomon Islands and New Guinea and had secured a very fine ethnological collection, part of which is being installed in the Auckland museum. He had lived a long time among the most primitive aborigines of the South Seas and had had many exceedingly novel and interesting experiences. He spoke of many curious religious superstitions, saying that the horn-bill often appeared in their carvings and seemed to have some religious significance. In certain of the dances the men act the parts of various birds and seem to actually think that they *are* birds for the time being at least. Before leaving, Mr. Holder presented a couple of Papuan fans to Dr. Stoner and myself, asking us to give them to our wives with his compliments.

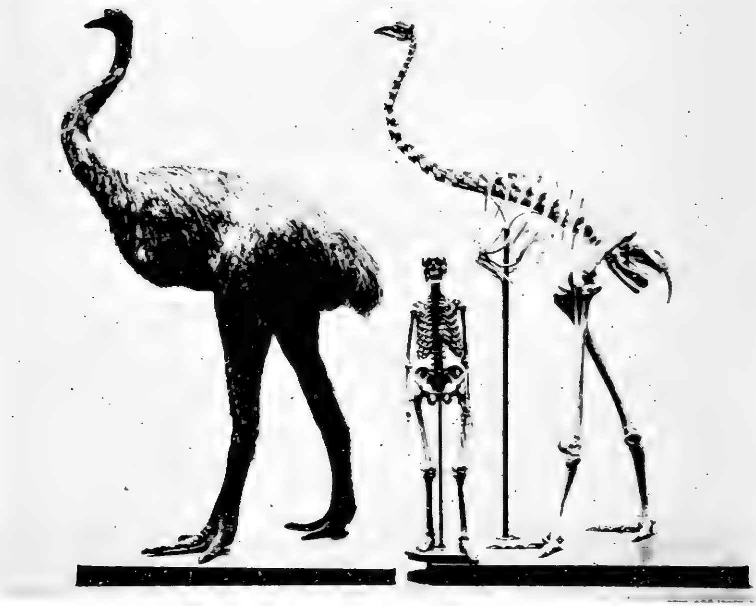
On the morning of July 17, Dr. Wylie came in on the Navua and our little party was once more intact. He reported successful work in Fiji and a most enjoyable voyage to Auckland which gave him a well earned rest. I then called on the U. S. Consul, Mr. K. de G. MacVitty, who had been ill for a few days and thus absent from his office when I had looked in once or twice before. He was very cordial, but seemed to think it would have helped our party in New Zealand if we had notified him in advance of our intended visit so that he could have prepared the way for a proper reception on the part of the Dominion Government. I told him that we were getting along all right and had thus far found it unnecessary to ask any Government concessions; that we were entirely content with the way certain citizens of Auckland had helped us out. We were to learn later of the great courtesies and material aid that would be ours when we reached the capital, Wellington.

The very next day I received a telegram from Mr. J. Hislop, Under Secretary of Internal Affairs, informing me that Mr. Hamilton, of the Dominion Museum at Wellington, had been given a permit to collect birds, and was coming to Auckland to arrange for a trip with Dr. Stoner, the material secured to be given to our museum. Several letters had passed between us and I was afraid that our ornithologist would have little opportunity to secure specimens. Indeed I learned afterwards that this was a very unusual favor on the part of the New Zealand authorities and that Dr. Stoner was perhaps the first foreigner who had been granted such a concession. The arrangement was entirely satisfactory as Mr. Hamilton proved to be a very good guide and ornithologist, and gave his services also in preparing the bird-skins after they had been collected.

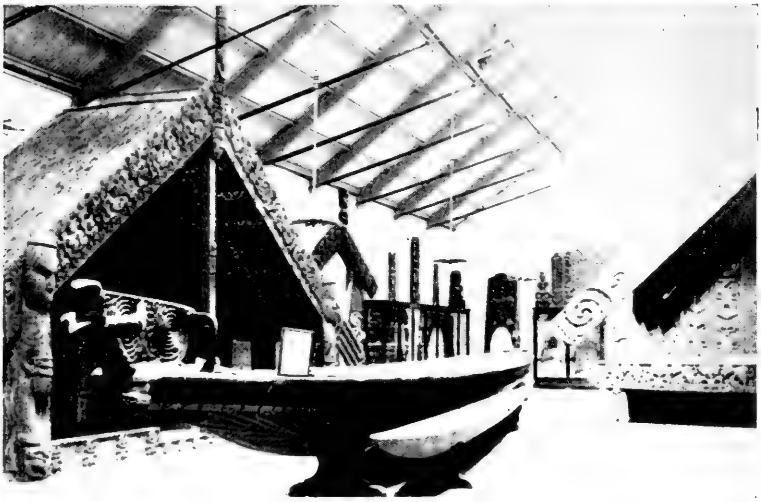
Thomas and Glock left on July 15 for a month's trip over New Zealand. They had carefully planned their itinerary and were bent on covering as much as possible of both the North and South Islands. We did not see them again until shortly before we sailed for home.

Stoner, Wylie and I got up early the morning of July 19 for the trip to Rakino. The launch Mavis was waiting for us at the pier and was a very able little boat, loaned for the occasion by Mr. Allison. We greatly enjoyed the run of twenty miles down the harbor and out into the Hauraki Gulf as the day was bright and sunny. Arriving at Rakino we found that there was no small boat to take us ashore and that the tide was too low for us to land at the little pier. So Skipper Foster ran her nose against the rock and we managed to climb down over the bows and get a footing on its slippery surface. The tide, although low, was not low enough, for the best collecting, which of course is always at the lowest possible ebb, comes only two or three days each month. Climbing over the rocks and around the headlands was hard work and there was no good beach. We found a few interesting things and some starfish were brought by the little bare-footed children of the caretaker of the island. How they could walk on bare feet over these rocks covered with sharp barnacles, worm-tubes and





Mounted group showing restoration of the Moa, its skeleton and some recent carinate birds for comparison (See page 187)
Restoration of the Moa and its skeleton, and a human skeleton to show relative heights (See page 187)
(From photographs donated by Mr Griffin, F.Z.S., Assistant Curator of the Auckland Museum)



Auckland Police Station (See page 181) (Photo by Stoner)
Scene in Auckland Museum, showing great Maori war canoe (See page 182) (Photo reproduced by permission of H. Winkelmann, Auckland)
A part of Queen Street, Auckland, showing the Post Office (See page 177)

mollusks was a mystery to me, but they did, and with no apparent discomfort. We collected a number of crabs, mollusks, tube-dwelling worms and the only medusæ secured in New Zealand. Stoner found some interesting insects.

A little after eleven o'clock the tide was high enough to enable the launch to reach the wooden pier, and we returned at once to Auckland in time for a late lunch.

On July 20 I started on the trawling cruise to which I will devote a short chapter later on, as it was a unique experience, full of interest and deserving of separate treatment.

After returning I found that the plunder secured during the cruise was sufficient to fill one of our collecting tanks and felt that the trip had been eminently successful. Mr. Griffin added some interesting material such as a basket-fish and handsome star-fish that the trawlers had brought him, thus completely filling the tank which was sealed and sent to Wellington with our other collections and equipment.

The Government Tourist Agent, Mr. Wallnutt, secured a ticket and berth for me on the fast train for Wellington, as well as hotel accommodations at that city. I called on our consul, Mr. MacVitty, and chatted awhile. He gave me a tip to the effect that we made a mistake in putting up at our humble quarters in Emily Place; that New Zealanders were impressed by externals and that we would do better at Wellington if we went to good hotels, instead of to rather obscure lodgings. This was doubtless true and we took the hint. Indeed I had already felt that it would be better to have more pretentious headquarters at the seat of Government and had secured a room at the Empire, one of the best hotels in Wellington.

There is a very good art museum in Auckland. I enjoyed a visit there shortly before leaving for the South, and found a number of excellent paintings of historic nature. One showed the ceremonial of tattooing, or face carving, that was so characteristic of the old Maori. Another represented the first sighting of New Zealand. A double canoe of great size was loaded with Maoris who had made the memorable voyage from Hawaiki and were in the last extremity of starvation. Many had fallen over the thwarts in collapse and I have seldom seen utter misery more strikingly portrayed than in their faces. A few leaders were standing and had just sighted the rugged headlands of the new world to which they were coming. It was one of the most striking dramatic pictures I have seen. Another large painting pictured the burning and plundering of a British ship by the Maoris.

That evening we took supper with Mr. and Mrs. Griffin, and found new reasons for wondering at the versatility of this remarkable man. He showed us a very fine painting of a pair of tigers, his own work, which had been accepted by the Royal Academy. He is apparently a real connoisseur in art, and his house is a marvelous treasury of choice things from various parts of the world. Among other things, he showed us two very large porcelain vases from China, each about five feet high, two large vases from Japan which were thought by the auctioneer to be of papier maché but they proved to be silver of rare workmanship, a very ancient bronze vase (Japanese), carved ivory boxes of texture so delicate as to resemble fine lace, smelling bottles encrusted with jewels, exquisite miniatures on ivory and many other articles of rare value. His main interest, however, seems to be in Egyptology and he is evidently a past master in deciphering ancient Egyptian inscriptions; he has written a dictionary of which he showed us the original manuscript, also volumes of translations of various inscriptions which he had been requested by explorers to make. He also showed us many valuable scarabs, an exquisite Venus in onyx, and other things taken from Egyptian tombs.

Taking it all in all we felt that in far away New Zealand we had encountered one of the most versatile and learned men we had ever met in all our travels. His home is a veritable museum of art and his wife seems to take great pride in it; but we could not help feeling that it must take a good deal of time and care to keep these numerous treasures properly dusted and that this priceless collection would be in great hazard were there children running about.

Mr. Hamilton, who was with us that evening, is connected with the Dominion museum at Wellington and is himself an exceedingly interesting man. He was a member of Sir Douglas Mawson's Antarctic Expedition, going as taxidermist. During the war, he served in England as a member of a special commission organized to circumvent the German submarines.

On July 27 Wylie left for Wellington with the intention of stopping off at several points of interest en route. After seeing him off, I called on Professor Wilson of the University College. He had a museum of well selected animal types and good laboratories for a limited number of students. It was a rather unusual fact that the University men of Auckland seemed hardly aware of our presence but we had no cause for complaint; some of them had been helpful to members of our party. As a mater of fact we had been too busy to care much for social amenities.

I said good-bye to the veteran curator, Mr. Cheeseman, and also paid a farewell visit to Mr. Griffin who certainly had done all in his power to further our work.

The next evening I left on the through express for Wellington, on the longest continuous railroad trip which can be taken in New Zealand, a distance of 426 miles covered in about 16 hours. The railways are controlled by the Government and seem to be well managed by Mr. R. W. McVilley, the general manager. The time-table is a Government printed book of 384 pages which can be carried in one's pocket. All train schedules, fares, distances, etc., are plainly set forth, together with the rules and regulations of the service. Tourist tickets may be had, good on all lines anywhere in New Zealand for seven weeks after issue, at the very moderate price of 16 pounds 5 shillings. The rates are really economical for one who travels a good deal and were used to advantage by Thomas and Glock of our party.

The Government Tourist Bureau will take any amount of pains to see that travelers are properly routed and will also attend to their hotel accommodations by wire in advance, all without charge. They also secure berths in sleepers. Indeed, the traveler is as well looked after as in our own country and sometimes the service is better. The giving and taking of tips is strictly illegal and I saw no evidence that the law was broken.

Members of the Legislature and many other Government officials travel on passes. No person can enter a carriage in which all seats are taken. Luggage up to 112 pounds in weight is carried for each passenger. "Left luggage" will be charged fourpence for each parcel and this charge covers storage for one month. A seat may be reserved on a through train from Auckland to Wellington for ninepence and a berth on the sleeper for twelve shillings and sixpence. These are but a few of the regulations concerning railway travel. Reduced rates are given for workers' weekly tickets, season tickets, family season tickets, weekly twelve-trip tickets, recruits for naval forces, young persons in employment, newspapers reporters, news-boys' season tickets, school season tickets, free school season tickets, school boarders, students of agricultural and technical colleges, New Zealand military forces etc.

I was told by a prominent Government official at Wellington that the railways in New Zealand are not self supporting, but that the service was so good and prices so low that they seem to meet with public favor in spite of the additional taxation incurred.

The cars, or as they call them, carriages, are much smaller than ours, as in England, and the sleepers are arranged more like our Pullman compartment cars with a corridor along one side and the berths placed cross-wise in the compartments; thus there is more privacy than in our Pullmans and the berths are narrower but longer and will not accommodate two persons. The dressing-room is very small and there is no hot water, nor is the car appreciably heated. Consequently I was uncomfortably cold in spite of what seemed to be an adequate supply of blankets. My room-mate was a Mr. Collins, a Government official concerned with industrial affairs who, much to my surprise, called me by name. It seemed that Mr. Sanford had told him that I would probably be on the train and requested him to look out for me. Hence I was well cared for and formed a very pleasant and helpful acquaintance.

We passed through the highest mountains during the night and the daylight run in the morning was through picturesque country. At a station we had a good breakfast for which we were allowed thirty-five minutes and charged the equivalent of sixty-two cents. The passengers were, of course, almost exclusively Colonials, very friendly and helpful to the casual stranger. The country we passed through early in the day was a beautiful rolling upland, white with frost; then it became more hilly with snow capped mountains in the distance and finally we ran along the rugged headlands of the west coast facing the Tasman Sea with the surf breaking high along the bold cliffs of the shore and the intense blue of the ocean beyond.

As we neared Wellington the country became quite wild and rough with very deeply cut valleys and sharply pointed hills, culminating in a very rugged area just before we reached the city.

While sitting in the smoking car I was addressed as "Professor" by the man sitting next to me and found that he had been a fellow passenger on the Niagara. He had been a captain in the British navy and commanded a submarine, if I remember rightly. He was very friendly and we passed several hours in conversa-

PLATE XXXV

The crew of the trawler "Cowan," Captain McKay second from left, standing (See page 195)
A catch of fish dumped on the deck of the "Cowan" (See page 198)
Emptying the trawl on the "Cowan" (See page 198)

PLATE XXXVI

The rocky coast of Rakino Island, Hauraki Gulf, New Zealand, showing uplift and the oysters clinging to the rocks (See page 184)
(Photo by Wylie)

tion. As a matter of fact the New Zealanders seem to me much more approachable and less reserved than the average Englishman. They form acquaintances and take a more lively interest in strangers than do the British or even passengers on our Pullman cars; but this I have found to be true of Colonials in general.

About noon we entered a series of deep valleys between abrupt, picturesque hills dotted with pretty houses, many of them of the bungalow type, much like those in the United States and differing greatly from the suburban dwellings found in England.

I was met at the station by Mr. Hislop, Under Secretary of Internal Affairs, with whom I had had some correspondence. This meeting was a turning point in our fortunes and Mr. Hislop proved a most powerful and efficient friend to all of our party. He had my luggage put into a government auto and introduced me to Mr. Oliver of the Dominion Museum who was instructed to take me in charge. We drove at once to the Empire hotel where a room had been reserved and I was informed that the government car and chauffeur would be at our disposal while we were in the vicinity of Wellington.

CHAPTER XII

EXPERIENCES ON A NEW ZEALAND TRAWLER AND NOTES ON THE INVERTEBRATE FAUNA OF HAURAKI GULF

The morning of July 20 was gloomy enough, as at daylight I hobbled down to the docks in my murderous New Zealand shoes, through a heavy rain and high wind, carrying a ponderous suitcase, blankets etc. The Cowan was at her wharf and Captain McKay welcomed me on board and assigned me quarters in his cabin. Although by no means palatial, the room was the best the boat afforded and the good skipper could do no more than give me his room and bunk in with his chief engineer, a very intelligent Scotchman by the name of Crawford, whose acquaintance I greatly enjoyed. The captain and his chief both being Scotchmen, were naturally quite chummy and I found them as fine types of the real British sailor-man as one can meet.

The cook served breakfast, and a good one, in my room which was on the upper deck facing the bows. Soon after starting we were bucking our way through very rough seas and the motion of the short, tubby Cowan, which was a sort of metamorphosed Sydney tug-boat, offered the height of acrobatic performance. Of course the motion seemed accentuated in my room on the top deck, but I managed by sitting on my up-ended suitcase, with the wall at my back and my knees braced against the side of the bunk, to have at least one hand free to manage the food. The crew were not so fortunate however, as they ate below in the forecastle and a big wave was shipped while they were eating, flooding the forecastle and drenching them and their food. They were used to such trifling misadventures however, and seemed not to be greatly disturbed.

It was so rough that we were soon forced to put in and anchor in a little landlocked cove in the island of Waiheke (I am not certain of the spelling) and waited there for the weather to moderate. The captain and I went ashore, although it was severe punishment for me to walk over the rocks in my partially crippled condition. The island is said to be about 100,000 acres in extent and is owned largely by Mr. Allison. Sheep and a few horses were grazing on the grassy slopes and seemed to be in good condition. We picked up a few mollusks along the shore, but found nothing of special interest and went aboard again before noon. Here we found that the cook, a typical cockney Englishman, had managed to cut off a finger while preparing the meat for dinner, and had keeled over at the sight of blood. They had bound up his wound however, and he went on with his work as if nothing had happened.

The Cowan was simply a tug-boat, about 80 feet long, given to fantastic performances in bad weather. The crew consisted of Captain McKay, Engineer Crawford, a mate, cook and three other hands, seven in all. When working they kept the trawl going night and day letting it down, or ''shooting'' it at intervals of about four hours. It is dragged over the bottom for three hours, then hauled up, and its contents removed, after which it is ''shot'' again. There were not enough men for two watches, so all hands were called every three hours to help get in the trawl, attend to the fish and ''shoot'' the trawl again. Much of the time they were wet either from water shipped by the boat which was sometimes swept by heavy seas, or from handling the trawl; and in winter it was always cold. Managing the trawl is no child's play. It is 120 feet long, 20 feet deep and has a very heavy mesh. It is hung so that when dragging along the bottom at a depth of from eighteen to forty-five fathoms it is on the starboard side, some distance astern and should hug the bottom at all times. When the three hours are up the net is reeled alongside by a reeling drum about amidship, set lengthwise of the deck and controlled by the mate. The trawl line is passed over the rail at the bend of the starboard bow and as it nears the surface the ends of the net are taken inboard by hand. During this process the boat rolls heavily at times and the men are often drenched by spume and sometimes by solid seas broaching over the rail. Sometimes the trawl is ''hung up'' or caught on the bottom and then the men, captain and all, have to exert every ounce of strength to break it loose.

After the ends and a considerable part of the trawl are taken over the rail, the fish are seen collecting in a ''purse'' or a bag formed by the central part of the net which is pulled in last and the immense purse appears with sometimes as much as a ton of fish. This is hoisted over the rail and inboard by the engine which works the reeling drum. It is then swung over until poised above the deck inside the rail when the men pick off the fish caught by their gills on the outside and the puckering string at the bottom is untied or cut and the whole mass dumped on the deck almost amidship. The fish flounder and flap around at a great rate. Then big baskets, each large enough to contain approximately one hundred pounds of fish, are brought up from the hold through the hatch, the larger fish are thrown in by hand and the smaller ones scooped up with huge shovels. The inedible fish, such as sharks, porcupine fish and others that do not command a worth-while price on the market are thrown overboard, the filled baskets are lowered into the hold and the deck washed down.

The trawl is then overhauled to see if there are any breaks or tears, which if small, are mended at once; the larger ones make it necessary to bend on a new trawl so that the work is not delayed. Again the net is lowered and all hands have a period of rest, or perhaps time for a meal, while the trawl is slowly dragging over the bottom for another haul.

These New Zealand trawlers work nearly all of the time. Once in about five days they run into Auckland by night, arriving there early in the morning, discharge their cargo of fish and in three or four hours are off for another five days' cruise. There is no Sunday rest for them as for nearly all other workers in New Zealand, although I believe they occasionally get a day or two in port.

Their life is one of severe work and constant discomfort; it is hard on the hands especially in cold weather, but they seem a fairly contented lot, taking their hardships as all in a day's work, having enough good food and earning a reasonable wage. I understand that the work is practically on a profit-sharing basis and so they are all interested in the success of each catch.

I noticed one thing on the Cowan which was unique in all my experiences with sailors. No matter how hard the work, how great the discomfort or how extreme the physical strain when the net was hung up, not a single oath did I hear from them during the cruise; I told the captain that this was the most extraordinary thing that I had as yet noted in New Zealand, that wonderland of the South. He said that swearing was not allowed on his vessel, that he and his engineer would not permit it and the men knew it.

My own life during this trawling trip was full of interest and novel experiences. Of course my situation was a comfortable one as compared with that of the others. To be sure I suffered a good deal from the cold and did not completely undress during the whole cruise; my bunk was narrow and trough-like with considerable topographic details in the way of hard bumps. But I slept well and greatly enjoyed the good meals which the cook climbed the iron ladder to serve in my cabin. To be sure the constant, often violent and erratic pitching and rolling of the boat was monotonous, but I was a "good sailor" and immune from sea-sickness, that blight on the pleasure of many who "go down to the sea in ships." The captain gave me a fine compliment when he remarked, "The fact is you're hardy!" which expressed a world of appreciation of my good behavior. Of course some of the refinements of home life were lacking, as for instance, anything whatever in the way of toilet facilities.

But this experience is one to be remembered with more than ordinary pleasure, for during it I made the acquaintance and formed friendships with *real men*, such as the captain and the chief, men who were hearty and genuine, who had had a world of experience and would swap yarns, sometimes by the hour, with the stranger in their midst. They were really interested in my work and every man on board was on the alert to find things they thought I would want. As soon as they got an idea what sort of specimens I was after they were eager to pick over the catch, and I thus secured many things of real scientific interest, so that I was able to end the cruise with a full cargo in the box which I had brought for specimens.

I was kept busy most of the time. With an empty oil-can I was at hand when the catch was dumped on the deck and after most of the fish had been put in the baskets I overhauled the debris that had been in the bottom of the purse, picked out anything that promised to be of interest, dumped it into the can, and examined specimens which the men brought for inspection. It should be noted that they usually waited until I was through before dumping the refuse over the rail and washing down the deck.

Sometimes when the trawl was down and supper disposed of, the skipper and "Chief" Crawford would spend an hour or so chatting in my room. Both of these men were wise in the lore of the sea and both were canny Scotchmen with wide experience in things marine. Captain McKay was a keen observer and knew much that was new to me. For instance, he had observed that the scales of New Zealand fishes are larger than those of similar species in British waters. They were both honest, God fearing men, steady and sober, used to privation and hardship. They were cheerful and uncomplaining and I remember that after a gruelling struggle in getting up the trawl, which was badly torn and spilled nearly all the fish, the captain was not at all ruffled and merely remarked, "A bit of bad luck wasn't it? but we expect it in our work." I could not help remembering how some skippers I have known would have made the air blue with their fervid profanity under much less pressure. I learned a good deal that was worth while from these two men, tossing about in the trawler in the Gulf of Hauraki.

To return to my note-book, I find that we spent the night of July 20 in the little cove where we ran for shelter; we got away at 7:30 the next morning, and reached the fishing grounds about 9 o'clock. We then shot the trawl and commenced the regular routine of work at sea. I spent nearly an hour overhauling a magnificent, finely-branched sponge about three feet in height which the captain had saved for me from his last trip. It was too large for me to attempt to preserve, but yielded several kinds of hydrocorallines, bryozoans, crabs, serpent stars and mollusks which I put away for further reference. We were dredging off Little Barrier Island and the trawl came up about one o'clock yielding about four one hundred pound baskets of fish, rather poor results. There were a number of interesting things for me, particularly some fine, large, bright red brachiopods, beautiful red and white striped anemones, a number of small corals, *Pecten,* chitons and serpent star. The trawl had dragged at a depth of about twenty-four fathoms over a shelly bottom composed very largely of the dead shells of a large *Pecten.*

That evening after dark the trawl was raised again but with great difficulty as it was "hung up" on the bottom, catching on what appeared to be a large sunken tree. It had also captured a large slab of volcanic rock looking like a good sized grave-stone. As a consequence the net was badly torn and most of the fish lost. The sea was sloppy and the men had a bad time generally, straining with every ounce of their strength to get the trawl in-board. As it would take several hours to bend on a fresh net, I went to bed after writing up my notes for the day.

It was a rough night but the morning of the 22nd was bright and clear. Going on deck I found that the captain had saved a part of the "tree" that had come up in the night haul. He had cut off about fifteen feet of it, letting the rest drop into the water. Imagine my amazement when I found that it was not a "tree" at all, but a part of a gigantic antipatharian coral! I noticed a few of what I supposed to be small colonies growing on the branches and found that they were really the ultimate branchlets of the whole immense colony. Tracing them down carefully I found them organically continuous with the whole of the fifteen feet of the tree-like object; and the very butt where it had been cut off showed the same thing. Judging from the weight of the part that fell back into the sea, the captain believed that the whole thing was several times as large as the part saved, and a reasonable estimate was that the entire colony had been twenty-five or thirty feet in height. This seemed incredible as I had never before seen an antipatharian over three feet in height.

I found that the men had saved a number of things for me during the night. There were many of the big brachiopods such as were secured the day before, growing on the *Pecten* shells, and often clusters of fifteen or twenty small ones were found inside a single shell. There were also some hydroids, simple corals, ascidians, anemones, sea cucumbers (too large for me to save), mollusks, serpent stars, crabs, etc. I succeeded in getting some good photographs of the crew, hoisting engine, trawl and the catch of fish as they were dumped on the deck. Another haul during the day yielded similar results, but with a few new things, although the fishing was still rather poor.

We saw the light-house that the Rona had rammed with such disastrous results. I found that it was useless for me to try to over-haul the catches during the night, as I was only in the way and could do little during the darkness. The crew, however, without exception were keenly on the alert for things that might be of interest, and picked over the mass of debris from the bottom of the trawl very carefully, thus saving a lot of things that would otherwise have been thrown away.

Among other things, they saved a number of gastropod shells of the remarkable genus *Xenophora* that have the strange habit of adorning themselves by affixing other shells to their whorls. They will be described later. The men had also saved two species of star-fish and some other things.

The next morning a fine crinoid came up, the only one seen during the cruise. It was one of the sessile kind and dark red in color. There was also a very large plumularian hydroid, many interesting simple corals, some beautifully red or pink in color, and a large serpent star. That day we were trawling off Little Barrier Island, which, like so many others has its tragic story.

It seems that a man, a sort of warden (for this is a bird preserve) and his wife were left alone there for several months at a time. On one of these occasions the man took sick and died and the poor woman had to dig his grave and bury him with her own hands in that lonely spot! and she lived alone beside his grave for several weeks before her signal was seen and she was taken off.

At the end of that day, July 24, my bottles were all full of specimens and the box which I had brought along was also practically filled with material which would not spoil in the wintry temperature before we reached port. All were carefully wrapped in cheese-cloth together with their labels, and I felt that my part in the work on the trawler was an emphatic success, in the way of novel experiences, acquaintance with real men, and its primary object, the collecting of marine invertebrates. Indeed, from the standpoint of the naturalist, that week had been by far the most profitable of the entire expedition, so far as I was concerned.

We ran into Auckland during the night and made port early the next morning, after a moderately successful cruise, from the fisherman's standpoint.

Two companies operated small fleets of trawlers out from Auckland. One was "The Municipal Council's fleet" of which the Cowan was one. The other, with larger vessels, was owned by the Sanford Company, which, I understand, had formerly had a practical monopoly of the business. I was told that both were fairly successful and that the Municipal Council's Fish Market had succeeded in keeping down prices to the consumer and thus attained the primary object of the organization.

I went ashore at about seven, after bidding good-bye to the captain, chief and crew of the Cowan and attempting, at least, to express my appreciation of the kindness with which they had made my cruise on the Auckland trawler one of the most interesting experiences of my life. May the world treat them as they treated me!

NOTES ON THE FAUNA OF HAURAKI GULF

Of course the trawler Cowan was engaged solely in securing fishes for the market in Auckland, and her crew had little incentive to observe or to secure other forms of marine life. The writer, on the other hand, was not prepared to preserve fish except very small ones, and was primarily interested in the invertebrates that came up in the trawl or were secured along shore during our infrequent landings.

Of the market fishes the most abundant and highly prized were the snappers, regarded by many as the most excellent food-fish found in New Zealand waters. The "Jack Dory" was probably second in quantity and esteem. It is a laterally compressed fish with a conspicuous eye-like marking on the sides. A very beautiful form was called the "frost-fish," and looked as if it were thickly coated all over with silver gilt, so perfectly silvered was it. It was some four or five feet in length, laterally compressed, very narrow with hardly evident scales, and was regarded as a good food fish. A number of soles were taken and I noticed that the crew preferred these to any other fish that the cook served. A few barracuda were also secured which looked much like those which are so prominent in the markets on our Pacific coast.

I casually noted some other forms, such as a few large porcupine fish, puff-fish, hammerhead sharks and other small sharks resembling dogfish, some rather large rays and a lot of small fry which were thrown overboard as soon as possible. Many of these fish would have made attractive museum specimens if properly preserved and mounted.

It was interesting to note the great difference in coloration between the reef fish of Fiji and those taken in from eighteen to twenty-four fathoms by the New Zealand trawler. Here were very few brilliantly colored forms, the frost-fish being perhaps the most attractive. But there was nothing to represent the gorgeous angel-fish, butterfly-fish, trigger-fishes or even the spotted morays of the coral reefs. As a matter of fact I had little opportunity to examine the fish. As soon as the trawl was swung in-board and its contents dumped on the deck, fishes were thrown or shoveled into baskets each holding about a hundred pounds and then the remaining ones thrown overboard. So I had to act quickly in picking out the invertebrates and getting them to a place of safety before the "clean up." The filled baskets were then stored away in the hold not to reappear until we reached our wharf at Auckland.

Only a few Crustacea were secured and these not of unusual interest except perhaps to the specialist. A small grapsoid crab from Rakino Island is diffusely mottled with scarlet over a yellowish background and the legs are obscurely banded with scarlet. Larger specimens, probably of the same species, have the carapace scarlet and spotted with white, and the distal parts of the legs are white underneath and scarlet, sharply barred with white, above. These pretty crabs are very common at Rakino and a number of specimens were secured.

Another form from the same place was bluish gray in color and the carapace of peculiar shape, orbicular in general outline, its surface with obscure squarish flat elevations and the lateral margins compressed into a thin plate-like ridge which ended rather abruptly somewhere back of the middle. The legs, and particularly the under surface, or rather, the reflexed abdomen, were quite hairy in the single female specimen obtained.

A peculiar form came from a depth of about 18 fathoms off Cape Colville. It was quite spiny and hairy with the legs ending in sharp curved claws. It bore a small hydroid colony attached near the bifurcated rostrum and in general resembled *Eurynome* as figured by Miss Rathbun in her "Crustacea from the North Pacific Exploring Expedition," Pl. IV, Fig. 2. Other spider-like crabs related to this were taken from sponges, a great number of which came up in the trawl, and a very small reddish anomuran bearing ova was also taken off Cape Colville.

The Mollusca were well represented in many of the hauls. Large areas of the bottom at depths of eighteen to twenty-four fathoms near Cape Colville were evidently covered thickly with shells, mostly dead ones of a fine *Pecten* bearing a superficial resemblance to our *P. irradians* or scallop, having the same beautiful sculpturing in the form of regularly spaced grooves extending from the hinge-line to the ventral margin, alternating with low, rounded ribs. Some specimens were about five inches in diameter. On the inside of the valves the ridges were angulated, not rounded, resembling thick straps which were narrower than the intervening furrows. Fresh specimens were pinkish on the outside and ivory white on the inside.

But these Pectens, although interesting in themselves, were of prime importance to the zoologist from the fact that they furnished an excellent foundation on which many other things established themselves and grew in great quantities. Bryozoa, tube-dwelling worms, whole colonies of small corals, barnacles, hydroids and a lot of other things were thus brought to light. But the most important of all, from our standpoint, was the splendid series of red brachiopods, whole colonies of them, big and little, which often occupied the inner or concave surfaces of these shells, in striking contrast to the ivory white background on which they grew. They were the largest living brachiopods I have ever seen and were in such numbers that we have a sufficient stock to use for laboratory purposes in our regular course in zoölogy.

The *Pecten* itself formed an interesting series in all stages of growth from about one-quarter to five inches in diameter. The younger specimens were oblong instead of orbicular in form, their length being in the direction of the radiating furrows, and they had more conspicuous wings.

Another large lamellibranch conspicuous in several hauls of the trawl was a handsome *Pinna*. These came up in quantities but were thin and fragile and most of them were broken, even when containing the live animal. The shell was about twelve inches long with a maximum width of five and one-half to six inches. The surface was very dark with a purplish tinge and, where the epitheca was removed, beautifully iridescent, quite as pearly as an abalone shell and showing the same varying tints. The surface was longitudinally corrugated and on the ridges were series of sharply lunate projections or ridges with their convex sides directed proximally. Inside, the shell was pearly on the proximal parts and dull brown and purplish distally, with a number of irregular corrigations and nodules. Many of these shells were overgrown with barnacles, bryozoans and worm-tubes. On the distal parts the lunate projections were extended into short tubes, expanded at their ends and incomplete on the side nearest the end of the shell. The muscle scars, probably of the great adductor, were very long and the muscles much expanded to form an extensive basis of attachment. A large, siphon-like tube projected backward from the visceral mass.

This *Pinna* produces pearls, and a number of these were presented to me by one of the crew on the Cowan. They were all small, almost black, and probably not of very great value.

Small edible oysters *(Ostrea)* were abundant on the rocky shores of Rakino Island and elsewhere in New Zealand. I understand that the largest and best come to the market from Stewart Island at the extreme south of the Dominion.

The sea-mussel *(Mytilus)* was also abundant on the shores of Rakino and doubtless at many other places on the New Zealand coast. I did not hear anything denoting its use as food by the colonials, although it is quite likely that the Maori used it. These shells were also used as foundations by many small barnacles and in some cases were almost entirely covered with the twisting shells of tube-dwelling worms. I could see no prominent points of difference between this mytilus and those of our own Pacific coast. A number of shells probably allied to *Cardium* were collected by Dr. Stoner at Waineki Island.

Among the gastropods the most interesting find was a species of *Xenophora.* This species has the remarkable habit of cementing to the whorls of its shell a whole series of other shells usually of a single species. Those which came up in the trawl on the Cowan all utilized the same species, a small lamellibranch probably belonging to the family Veneridæ. These are arranged in close series around the distal whorls, quite evenly spaced and always with the concave or inner side up. Impressions throughout the entire spire of the *Xenophora* show that it commenced this style of ornamentation quite early in life, and it is evident that if all the shells remained in place there would be several whorls of them outlining the whorls of the host. Toward the apex of the spire, however, fragments of other shells are cemented on. Is it possible that *Xenophora* improved its method with age and experience and finally adopted a uniform ornamentation by using the same bivalves throughout, attaching all of them with the same surface upward? Or did it use the same shell throughout because it lived on a bottom where that shell is most abundant and perhaps the only available material?

In the volume of the Cambridge Natural History on Mollusca, p. 64, Rev. A. H. Cooke says: "The singular genus *Xenophora* protects itself from observation by glueing stones, shells and various debris to the upper side of its whorls. Sometimes the selection is made with remarkable care; the *Challenger,* for instance, obtained a specimen which had decorated its body whorl exclusively with long pointed shells."

It seems to me that this device is hardly protective as it renders the *Xenophora* more conspicuous than it naturally is. Neither can I conceive of it as decorative in any purposeful sense. The problem is not solved by either of these theories but no other presents itself and it will have to remain one more "unsolved mystery of the deep."

The specimens were often found almost completely immersed in a large soft sponge, all but the lower part of the body whorl being entirely covered. They were brought up in the trawl from a depth of about twenty-four fathoms, while we were working near Little Barrier Island, Hauraki Gulf.

A number of other gastropods were secured, some of them very beautifully sculptured, but none requiring special mention here, although it is hoped that the specialist (probably Dr. Paul Bartsch of the United States National Museum) will find something of interest.

One species seemed to be a sort of shell-less *Patella,* having the general features of that group, but without any trace of a shell. The specimens are a little less than an inch in length and almost black in color, with the dorsal integument so thin that the coiled intestine can be seen through it. On the head there is a pair of short stumpy tentacles. The foot is very regularly oval in shape, muscular, and under the edge of the mantle are a number of gill lamellæ. Dr. Paul Bartsch, from my verbal description, thinks this may be an *Onchidium*, a shell-less pulmonate.

I have been unable to find any reference to Patellidæ without shells and may be far afield in my identification. The species resembles the Amphineura or Chitons in many respects, and there are chitons which do not bear shells. We understand, however, that only one genus of this group has a distinct head, and that is a worm-like form very different from the one here described. These were collected on Rakino Island. A number of very prettily marked *Patella* shells were secured at the same place. They had radiating ridges of dark brown running from the apex to the margin, alternating with furrows of a much lighter color.

There are several species of chitons in the collection, most of them from Rakino Island. One is a uniform dark grayish olive, ranging to almost white in some specimens. These are small forms only about three-quarters of an inch long in which the girdle is made up of diamond-shaped plates or spicules. The ctenidia are relatively large and extend nearly the whole length of the foot. Another chiton, collected by the trawler from a depth of thirty to forty fathoms, is quite different, being about an inch and a quarter long. The plates are elaborately sculptured with fine, raised ridges extending directly across them parallel to the long axis of the body, and each plate is strongly keeled in its center. The anterior plate is very conspicuous, its back border elevated centrally into a sort of shallow beak and its surface marked by very prominent, nodulated ridges radiating from the beak to the rounded front border, giving a fan-like effect. The girdle is covered with small granular spicules and the pleura of the valves bear rounded nodules on their edges, but are otherwise quite smooth. The foot is long and narrow and occupies a relatively small space, the shell extensively over-lapping it on each side; the ctenidia are not visible without dissection. In one specimen the foot is reduced to a mere strip.

Still another chiton from Rakino is rather clear light gray with a series of very dark, almost black spots on the middle of each plate where the keel usually is and similar dark blotches almost bar-like, extending across the mantle, the latter covered with diamond shaped spicules. The foot is much larger and broader than in the species last mentioned.

The most striking thing in the collection of *Echinodermata* from Hauraki Gulf is the entire absence of Echinoidea, for not a single sea-urchin was found. A very fine star-fish brought in by a trawler was turned over to me. I am unable to even approximately identify this form as it will go into no family description which I can find. It has five short triangular rays and a very large disk. The spread measures nine inches and the disk, four inches across, is almost flat and very slightly vaulted. At the tip of each ray are two very conspicuous smooth, polished bean-shaped plates, in contact at their distal parts. The dorsal surface of the rays is crowded with papulæ and covered with a series of hemispherical, sometimes sub-spherical, spines with polished surfaces looking like round cobblestones. Crowded in between these are many smaller sub-globular spines, some of which seem to be distorted by over-crowding.

The madreporic body is nearer the center than the margin of the disc, is somewhat irregularly oval in form with a longitudinal furrow in the center and very fine vermiform striations. On the lower surface the spines are like those on the dorsal side but considerably smaller and here occasional two-pronged pedicellariæ can be detected while papulæ are absent.

The ambulacral feet are in two rows and have very large, powerful suckers. The ambulacral grooves are flanked by a row of short, club shaped spines each of which is usually accompanied on the side nearest the groove by three smaller and more slender club-shaped spines.

The marginal plates are not evident externally and thus the species would appear to belong to the order Cryptozonia as defined by Sladen in his Asteroidea of the Challenger Expedition, but I am unable to place it in any of the families defined by him.

A single specimen allied to *Luidia* and another to *Archaster* complete the list of Asteroidea which we obtained from Hauraki Gulf.

Among the serpent stars a small species was represented by several specimens from a depth of about eighteen fathoms off Cape Coville. It appears to belong to the genus *Ophiozona* and has a spread of about an inch and a half. The dorsal surface of the disk is covered with large, irregular, protuberant plates like cobblestones, big and little mixed together without any apparent regularity, the radial shields appearing like the other plates but larger, and between each pair is a series of linear rounded plates ending in a transverse row of three at the distal end of the radials. The upper plates are undivided and imbricated as are the lower ones. There are teeth and mouth papillæ but no tooth papillæ and the side mouth shields do not meet at the point of the jaw. The arm spines are short, lying parallel to the side arm plates and are usually three or four in number. Tentacle scales are single, thick, oval. The genital slits are so concealed by the plates that they can not be seen without dissection. The preserved specimens are light gray with the arms obscurely barred with light red.

Another serpent star from the same locality had a leathery disc like *Ophiocoma* but I could not make out any mouth papillæ. The serpent stars were usually badly mangled by the trawl and in poor condition for study.

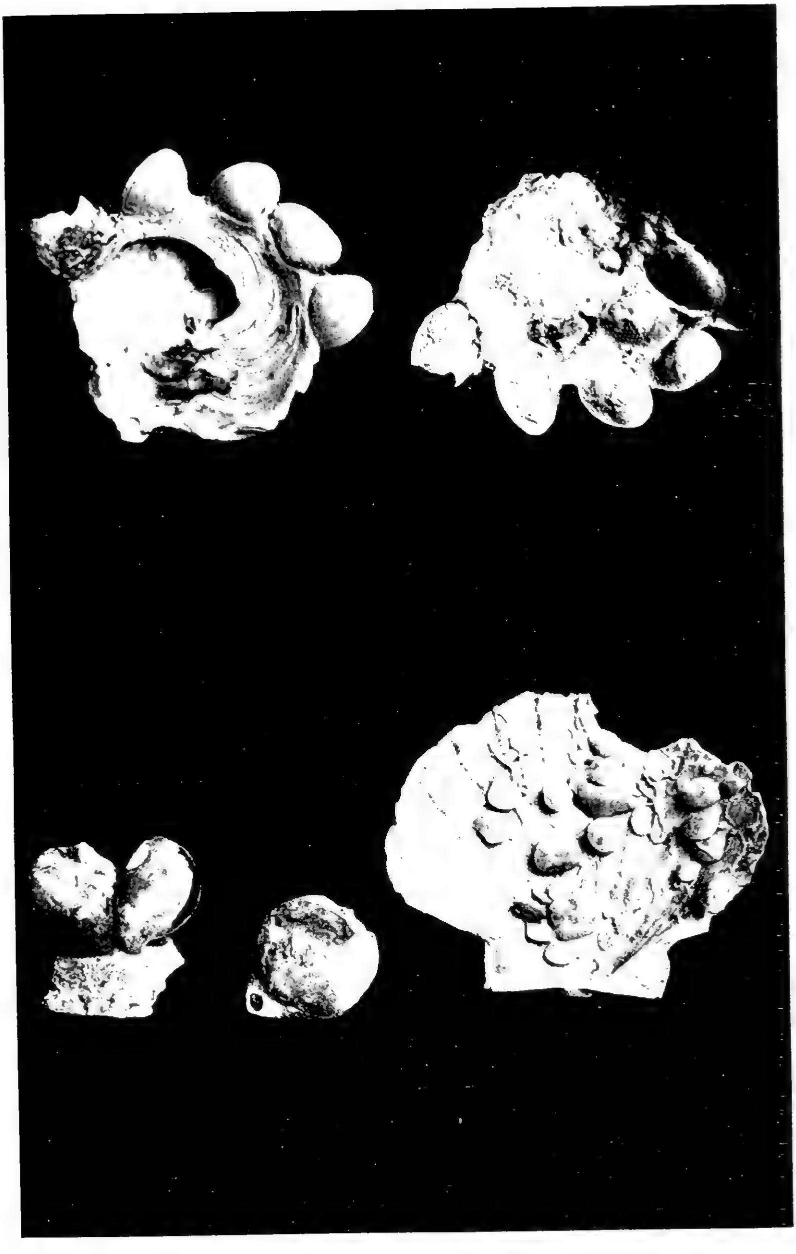
Some very fine, simple-armed basket-fish were brought in to the fish market at Auckland and turned over to me. They were attached to gorgonian and antipatharian corals, as is so frequently the case with this interesting group. One was very strikingly colored, the arms sharply ringed with very dark brown, almost black, and narrow red bands; and the disc marked by sharp radiating lines of light red on an almost black background. The arms seem to be unbranched to the very tips and are exceedingly stiff and wiry, not at all like the flabby *Ophiocreas* of West Indian waters. There is a series of furrows alternating with the radiating ridges on the dorsal surface of the disc and also a central depressed area. This form superficially resembles the West Indian *Astrocnida* described by Lyman, but is without terminal branchings to the rays and differs in several other respects, such as in the absence on the disc of the stumpy spines so characteristic of that genus.

Another simple-armed basket-fish has the same color as the last but doubtless is generically distinct although resembling it in having unbranched arms. The disc however has very prominent radial shields, the color is a uniform light reddish brown all over and the tentacle scales are much more prominent. It was found on a branch of an antipatharian coral. But in spite of the unbranched condition, these forms are really basket-fish and belong to one of the genera described by Lyman as included in the family Astrophytidæ. By far the majority of these simple-armed forms were first described from the West Indies. Since then a number have been secured from the Pacific and several in the Dutch East Indies by the Siboga Expedition and reported by René Koehler.

Two specimens of free or sessile crinoids were taken from a depth of twenty-eight fathoms. One of them is a very handsome red specimen which came through intact, but I dare not take the chance of its going to pieces in an attempt to remove it from the bottle so I will leave it for a specialist to examine.

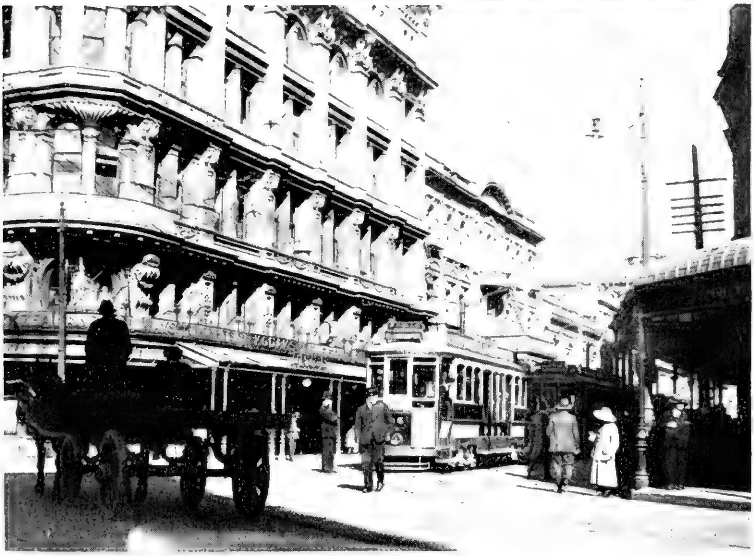
Few worms were taken during the cruise on the trawler, but large masses of worm tubes were found on Rakino Island belonging to a form allied to *Serpula vermicularis,* also one belonging to the family Cerratulidæ and a couple of *Nereis*-like species.

As already mentioned, great numbers of handsome, red brachiopods were brought up in the trawl when working over ground covered with *Pecten* shells. Some individuals were as much as one and half inches long and one and a quarter inches wide, the largest living members I have seen of the order. It probably belongs to the genus *Magellania,* figured and described in Parker & Haswell's Textbook of Zoology, Vol. 1, pp. 360-366. These authors say that this species *(M. lenticularis)* is found in great numbers at moderate depth off the coast of New Zealand. Our specimens agreed very well with the figures given in that work. One *Pecten* valve bears on its inner surface about twenty of these beautiful brachiopods in various stages of development. The larger specimens are very well adapted for laboratory purposes as they furnish a study of a typical brachiopod, the large lopho-



Ventral and dorsal views of *Xenophora*, a gastropod which ornaments itself with bivalve shells (See page 204)
Left—Large brachiopod shells, dorsal and ventral views (See page 199)
Right—A *Pecten* shell on which numerous brachiopods are growing (See page 199)
All figures are 1-3 natural size

PLATE XXXVIII



Government Buildings at Wellington (Photo by Stoner)
Parliament Buildings at Wellington (See page 222) (Photo by Stoner)
View on Willis Street in a busy section of Wellington (See page 225)

phore being very conspicuous and the other parts being correspondingly well shown.

Fine colonies of *Bugula*-like Bryozoa were brought up from eighteen fathoms off Cape Colville. These show the avicularia very plainly.

Among the Cœlenterates are a number of interesting things, the most surprising being the immense antipatharian already described. Some fragments of this specimen were saved but hardly enough to serve as a basis for description. The colony was very irregularly branched like the scraggly branch of an oak. Other specimens were bush-like in form, one, from which some of the simple-armed basket-fish already described were taken, being entirely clothed with an investing compound reddish brown actinian of a rather leathery consistency. This specimen was at first taken for an alcyonarian colony.

Very beautifully colored anemones came up rather frequently attached to *Pecten* shells. Some of them were about three inches broad with a body height of two to three inches, regularly marked with alternating bright red and white longitudinal stripes, making a pretty pattern. The tentacles were red and very numerous. A slaty blue anemone of very convenient size for laboratory study was common on the rocks bared by low tide at Rangitoto Island, where they were collected by Dr. Stoner; others were found at Rakino Island.

A large gorgonian belonging to the family Gorgonidæ was trawled from Mercury Bay near Auckland. This is interesting as being the only flexible coral found on our cruise. The group seems to find its center of distribution in the West Indies where it is one of the most characteristic features of the reef fauna.

Several colonies of a fine alcyonarian were also taken off Cape Colville from a depth of eighteen fathoms. These grew in clumps of short branches borne on a short thick stem which, contrary to the usual custom in this group, is not sterile, but bears thickly implanted polyps. On the short stumpy branches the polyps are practically contiguous. There are no evident calyces, especially when the polyps are retracted, and the spicules are small tubular spindles thickly implanted in the body and tentacles. The color of the colony is a light or salmon pink. The polyps are not completely retractile but are protected while partly retracted by the spicules on the infolded tentacles.

Many simple corals were found growing on *Pecten* and other shells dredged from a depth of eighteen to twenty-four fathoms. One of these has an oblong corallum resembling a small *Fungia* measuring one and three-eighths inches long and a little more than half an inch in width. It doubtless belongs to the genus *Flabellum.* The septa seem to be in four series and the corallum is unusually deep. It came from off Colville Island and is the largest single corallite in the collection.

Another form was rather profusely branched and bore some resemblance to an *Oculina,* one of the true reef corals. The individual corallites are tubular with circular apertures and no evident costæ. They are about four mm. in diameter and the colony consists of a dense clump of slightly separated corallites resembling *Dendrophyllia manni* Verrill as illustrated by Vaughan in his work on Hawaiian Corals. But our specimens have no costæ.

A very delicate, branching, white hydrocoralline was also brought up in the trawl. The gastropores form perfectly round holes in the surface of the branches but near the tips they are cut obliquely and the margin is exserted on the outer side forming a sort of scoop-like projection.

There are several interesting things among the hydroids and it is evident that a thorough exploration of Hauraki Gulf would yield important results in this group. The following may be mentioned as occurring in our collection:

Halecium robustum Allman. This species has a thick, fascicled stem and sessile hydrophores and was taken by the Challenger off Cumberland Bay, Kerguelen Island, from a depth of 105 fathoms. Curiously enough I found it in the material of the Harriman Alaska Expedition and gave it the same name, as a new species, overlooking its apparent identity with the form described by Allman.

Synthecium, sp. A specimen from off Cape Colville shows the gracefully recurved and finely rimmed hydrothecæ characteristic of this genus, which was originally described by Allman from specimens from New Zealand, although it has since been reported from various other parts of the world.

Sertularella. A species of this widely distributed genus is from the same locality as the last. The hydrothecæ are tridentate, the teeth low, inconspicuous, and large. The gonangia are characteristic of the genus being very evenly corrugated like Japanese lanterns with a tubular neck and an aperture with everted or trumpet-shaped rim.

Several small forms such as *Hebella, Lafœa* and other campanularians were found growing on the larger hydroids.

A delicate plumularian belonging to the type genus Plumularia was found on the *Sertularella* mentioned above. This evidently belonged to the "Catharina group" as defined in the writer's "American Hydroids," Part 1, the Plumularidæ, p. 55, and probably is the well known *Plumularia catharina* Johnston. A number of very beautiful colonies were secured. The numerous species of *Plumularia* intergrade so frequently that it is almost impossible to separate them according to any consistent system.

By far the most spectacular hydroid secured was a great clump of plumularian colonies twelve to eighteen inches high, dark brown in color, with thick fascicled stems and numerous branches. This fine specimen evidently belongs to the genus *Lytocarpus.* The gonosome is in the form of a pseudo-corbula of separated, protective branches which inclose an oval space over the part of the hydrocladium on which the gonangia themselves grow, the whole affair being much like that of *Lytocarpus formosus* Fewkes. The hydrothecal margin is quite oblique and strongly dentate, and the mesial nematophore attains the level of the margin. This form may prove to be new, but the writer does not think it advisable to insert descriptions of new species in the present narrative.

CHAPTER XIII

IN AND ABOUT WELLINGTON, CAPITAL OF NEW ZEALAND

A good room with a fireplace at the Empire hotel was certainly a much appreciated luxury, although it involved an extra charge of three shillings a day; but it was worth it.

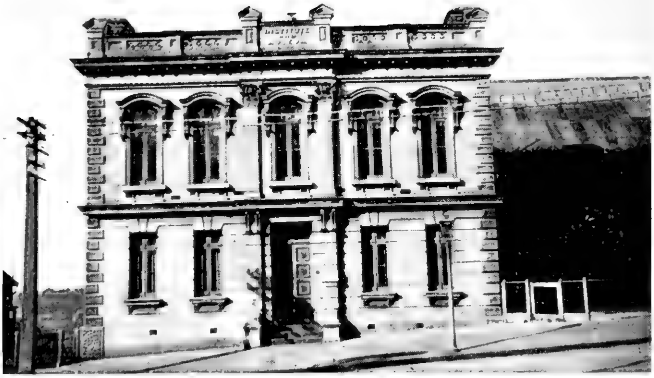
After lunch, Mr. Oliver took me in a government auto to visit the University. There we met Professor Kirk, the zoölogist, to whom I owe many courtesies. He is doing excellent work and is very active as a teacher and as a research man. We took four o'clock tea in one of the college buildings where I met a good many of the instructional staff. These teas are a regular part of the daily routine in all British colleges and serve a valuable social purpose in furnishing a daily point of contact between all the teachers. Professor Kirk arranged a collecting trip on which he expected to show me live *Peripatus,* one of the objectives of our visit there. He also hoped to show me a serpent-star that undergoes a direct development without the metamorphosis characteristic of echinoderms in general.

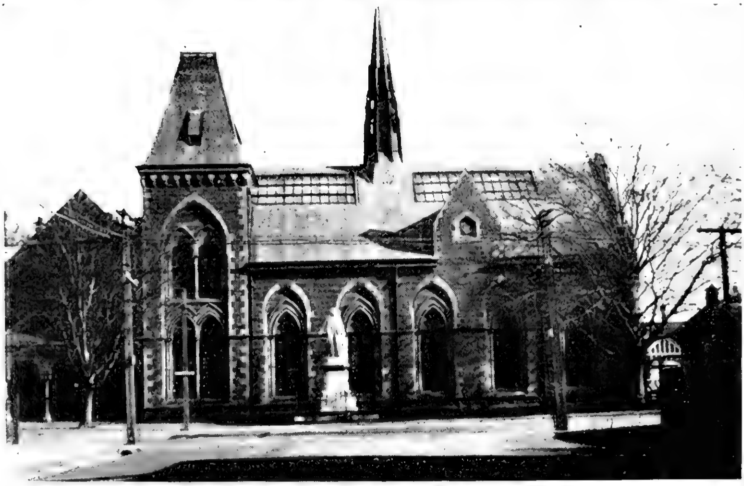
I then went with Mr. Hislop to call on Mr. Cecil Day, Official Secretary of his Excellency, the Governor, Lord Jellicoe, to whom I delivered my letters of introduction from our Secretary of State and the British Ambassador at Washington. We called also on the Hon. Downie Stewart, Minister of Internal Affairs, with whom I had a short but satisfactory interview. The minister is crippled greatly from rheumatism contracted during the war, but carries on very efficiently in spite of the handicap.

Then back to the hotel for an excellent dinner and a pleasant room which was actually comfortable, my first experience of the kind in New Zealand. Although this luxury was expensive I found that it was to the interest of the University and our expedition to occupy better quarters than we did in Auckland, remembering what Consul McVittey had said regarding the matter of "externals" in New Zealand; moreover, as we were paying our personal expenses this involved no extra expense to the University. That night I slept in the most comfortable bed I had

Victoria College, Wellington (See page 225) (Photo by Stoner)
Canterbury College, Christchurch (See page 235)

PLATE XL





Auckland Museum (See page 231) (Photo by Stoner)
Dominion Museum at Wellington (See page 232) (Photo by Stoner)
The Canterbury Museum at Christchurch (See page 229)

occupied since leaving home and enjoyed a good hot bath next morning.

The following day I called at the American Consulate and found the Consul General was away on a trip to the United States, but the Vice Consul, Mr. Moran, was quite cordial and said that he had been expecting us. After reading my letter from the Secretary of State he remarked that I was exceptional in not appearing to want any particular favors, explaining that he generally had to deal with sailors and men who were down and out and not particularly creditable citizens of the United States. He expressed the belief that a visit from our party of scientists would give a much better impression and be a real aid to his office.

Professor Kirk took me on the promised hunt for *Peripatus,* that strange link between the worms and arthropods so valuable for purposes of instruction. We went to a beautiful hilly park, much of it in its primitive condition, with many shady paths, enchanting vistas of tree-ferns and other strange trees and plants. Indeed this was one of the most picturesque spots I have ever seen and I knew it would give supreme pleasure to Professor Wylie, our botanist, when he visited it later.

Peripatus, a small caterpillar-like creature, lives in thoroughly rotted moist logs and stumps, is carnivorous and is capable of greatly extending and contracting its body. Dr. Stoner, who captured a large number of them, will give a more adequate description in his account of his experiences in New Zealand. Professor Kirk dug and scraped into decayed logs with a long knife resembling the hunting knife of our pioneer days and found several of the interesting creatures, and I was allowed the pleasure of digging out some of them myself. He said they are best killed in slightly warm water and are thus prevented from retracting, indeed they expand before dying.

In the evening Mr. Hislop took me to the Savage Club, a social organization found in all places of importance of New Zealand and corresponding in part to our Rotary clubs at home. We found the hall packed with men, most of them smoking, and witnessed the installation of a new Chief Savage, who sat on a small platform on which were hangings to represent a tent, and provided with a gavel made of a human thigh bone. I seemed to be the guest of honor and was invited to occupy a seat beside the Chief Savage. There was an excellent orchestra of about thirty pieces, and a lengthy program occupied most of the evening. Real ability was shown in the various stunts which were put on after the orchestral numbers.

I was told that the audience represented the brainy element of Wellington and that I was expected to address them briefly. The chairman said some very pleasant things about the United States in the course of introducing me and I was received with prolonged applause. I spoke very briefly, remarking on the value of "good terminal facilities" in both railways and speakers, and sat down after extending greetings from America and the State University of Iowa, to which they responded with generous clapping of hands.

An informal lunch was served when the program was about half over and we adjourned to coffee and sandwiches, with beer for those who wanted it. The Chief Savage acted as my escort and insisted that I accompany him back to the platform to hear the remainder of the program. I was introduced to several of the gentlemen present, but my wretched memory serves me so badly that I recall the names of but few of them. Among them was Mr. Drew, Government Publicity Agent, who arranged for an interview with a newspaper man. I also renewed my acquaintance with a fellow passenger on the Niagara who lives at Christchurch. Learning that I hoped to visit that city in about a week, he warned me that I would have to reserve my hotel accommodations at once as it would be "Race Week" and the city greatly crowded.

Mr. Hislop accompanied me to the hotel which we reached at about eleven o'clock to find the door locked! A servant responded to our knocking, however, and I was admitted. As this was one of the most pretentious hotels in the Capital of New Zealand I was naturally surprised, but was told that it was a custom of the country.

Before leaving the hotel to go to the Savage Club I had been handed an official letter which I put into my pocket and forgot until after I was in bed that night. It was a formal invitation to an eight o'clock dinner to be given by His Excellency, Governor Jellicoe and the Viscountess Jellicoe, on August 2. This was an honor I had not anticipated, but thanked my lucky stars that I had my dress suit along.

On Sunday July 30 it rained in the morning and I spent most of the forenoon writing in my cozy room; among other things wrote an acceptance to the invitation of Lord Jellicoe. I also took a walk to get my bearings in Wellington, a city almost as irregular as Auckland, placed in a deep valley surrounded by high hills on three sides and facing the beautiful harbor on the fourth.

After lunch, Professor Kirk called in a government auto and took Mr. Oliver and myself on a delightful ride along the coast. The scenery was most picturesque. The shore was rugged with its projecting rocky headlands and rock-strewn flats which, owing to an almost vertical stratification, are carved into weird and fantastic shapes, while the heavy surf breaking against their bases in huge foaming rollers contrasted with fine effect with the deep blue of the sea beyond.

We left the car on the shore of Island Bay and worked awhile on the rocky flats, although I was a little lame and wanted to save my only good American shoes, having conceived a violent antipathy to New Zealand foot-wear, an antipathy born of sad experience. Professor Kirk is admirably well acquainted with his local fauna, as is usual with British naturalists, and is a most energetic and enthusiastic collector. We were particularly anxious to secure specimens of *Dolichoglossus,* a near relative of *Balanoglossus,* and found them in abundance. The species is a bright scarlet in color but quite small. We secured a good series including many embryos of various sizes. The marine fauna is very rich and is well worked by local naturalists. We found many chitons, limpets and other mollusks, two species of star-fish, several serpent-stars and many other interesting things.

It was very cold work collecting among the wet rocks and seaweeds, and my hands became so numb that they were practically useless. Professor Kirk and Mr. Oliver were used to the temperature and seemed to mind it very little.

On the way back we stopped at Mr. Oliver's house where we saw his very attractive wife and baby. He is an able, hard-working young zoölogist, interested mainly in ecology, and has developed a remarkably effective system of keeping notes, photographs and printed matter regarding individual species, for ready reference, all of which he explained in a very interesting way.

In the evening, Professor Kirk took me to his laboratory to care for the specimens collected at Island Bay that day. He was dubious about the *Dolichoglossus* being properly preserved, but saved it in fairly good shape.

The next morning I visited the Dominion Museum which is housed, unfortunately, in a wooden building and the material is in a very crowded condition. The Maori collection was very good and I saw many elaborately carved stern-posts for canoes, the spiral design predominating as usual, nets, fish-traps, model canoes, dipnets, carved bailers, etc. There was a very interesting model of a Maori village "Pa" or fortification enclosed in an elaborate series of stockades and trenches. Inside were a number of typical houses and some storehouses built in the tops of trees.

Considerable aboriginal clothing was exhibited, including feather capes and cloaks, some made of kiwi feathers and others of dog-skins. There were a number of garments made of the New Zealand hemp. A very fine entrance to a Pa was made of two great slabs resembling totem poles with another very wide and heavy slab constituting the door proper, all elaborately carved with grotesque figures and stained a deep red.

I called at the Consulate to get pointers regarding the Governor General's dinner and the proper etiquette to be observed and was informed that it would be much like formal dinners the world over, that Lord Jellicoe was quite democratic and much liked by the people here. The Vice Consul again assured me that the visit of our party was fortunate inasmuch as it proved that Americans were not all money grabbers, which was too often the impression given by those who visited New Zealand. Mr. Hislop was also good enough to say that the talk at the Savage Club had made a favorable impression.

I went again to the museum and was shown around the zoölogical section by Mr. Oliver. The exhibit is impaired by poor lighting and is too much crowded. There is a complete skeleton of a moa, all of the bones being from the same individual bird. The outstanding feature of the collection is a series of whales' skeletons and skulls including some types which I had not seen before. Mr. Oliver has written several valuable papers on these New Zealand Cetacea. There is also a good series of the invertebrates of the country. Mr. Oliver said that he had arranged for the storage of our boxes in his office where we could keep such of them as we wanted to get at, while the others could remain at the express office until we were ready to ship them home.

At the museum I was so fortunate as to make the acquaintance of Mr. Elsdon Best, an outstanding authority on all matters relating to the Maoris or native New Zealanders. He said that the best popular account of the famous canoe voyage was in "Hawaiki, the Original Home of the Maori," by S. Percy Smith. Maori is a word used throughout Polynesia to indicate native people or aborigines and should not be applied exclusively to the New Zealanders, who came originally from Rarotonga and Tahiti. Mr. Best told many interesting things about the famous canoe voyages. The first canoes to arrive found New Zealand uninhabited but those coming some two hundred years later found the "Pre-Maori" on the coast of North Island. These were negroid people and probably came from the New Hebrides or New Guinea and were regarded as an inferior race, although the Maori immigrants intermarried with them. The spiral design so prominent in the Maori carvings is entirely unknown in Polynesia where rectilinear designs prevailed and still prevail. People do not change their traditional designs spontaneously and Mr. Best thought that the idea of the spirals was introduced by the pre-Maori race from the West where it was, and is, frequently employed, particularly in the New Hebrides. Mr. Best has a great quantity of manuscript regarding Polynesian ethnology in shape for publication. He is a strikingly fine looking man over sixty years old, with an erect military bearing and remarkably keen eyes and alert manner.

I called on the manager of the Government Tourist Bureau, Mr. Wilson, who generously promised to send us photographs and lantern slides for publicity purposes and to do anything else in his power to help us attain the objectives of our visit.

On August 1 Dr. and Mrs. Stoner arrived in Wellington, accompanied by Mr. Hamilton, who had been helping in the collection of birds for our museum, and very efficiently too.

Mr. J. McDonald, Acting Director of the Dominion Museum called in a government auto to take me to the Art Gallery and then to Parliament House, a beautiful marble structure of classic design, where he showed me the native committee room very effectively decorated in Maori designs. We were then joined by Mr. Hislop and took a delightful ride to Observation Hill where we had a superb view of Wellington with its harbor and other environs. The scenery reminds one of Switzerland; many of the cottages nestling on the hillsides and in the valleys resembling Swiss chalets. The drive offered one enchanting vista after another. We stopped at Mr. Hislop's home which commands a superb view of forest, or "bush," mountains, valleys, and a glimpse of the distant sea. The house was from an American design and really beautiful. I then had the pleasure of meeting Mrs. Hislop, and found her a very kind, charming hostess. Then home in the evening twilight along a winding road, each turn presenting a new and beautiful picture.

Wylie came and chatted a while in the evening and told me something of his trip in the North Island during the week since we parted in Auckland. We enjoyed my fire-place and had a cozy talk, exchanging our New Zealand experiences.

The next morning, August 2, I secured my steamer ticket for Christchurch, South Island, and reserved a room at the St. Elmo hotel there. I also had a conference with Mr. McDonald regarding exchange of museum material between the Dominion Museum and our own and found him ready for hearty coöperation. He promised to donate several "Tuatara" (*Sphenodon*) one of our main objectives in New Zealand. We then visited the Girls' College under the direction of Miss McLean, who has spent much time in the United States and seems to be a really progressive woman. We visited a number of her classes and greatly admired the fine appearance of the pupils, who are about the age of our high school girls. The most remarkable fact that I noted among them was that not one of them wore glasses and I was assured that there was no eye trouble among the several hundred girls in the college.

After lunch I was interviewed by a reporter from the Evening Post and then Mr. McDonald called in a government car. We picked up Mr. Hislop and took a delightful drive along the coast, stopping at Scott College, a Presbyterian institution in charge of Dr. Uttley, who showed us around. The institution was modeled after the best type of English boys' schools. Here we took afternoon tea, the inevitable accompaniment of an afternoon call wherever the British flag waves. Mr. Hislop very thoughtfully placed a government car at my disposal for the evening which was rendered memorable by the Governor's dinner.

This was really a wonderful experience for an American professor not used to the etiquette of Vice-Regal courts, and seems worthy of rather detailed description. The car called for me at 7:30 and we joined the procession of autos in front of Government House at 7:55. An aide in uniform met the auto at the door and showed me to the cloakroom where I was handed a card with the name of the lady whom I was to take in to dinner, and also indicating our places at the table. We were then ushered into a very large, brilliant reception room where I was introduced to a number of notables, many of them resplendent with decorations and jeweled orders and ribbons, while I wore only "the conventional black" and a Sigma Xi pin for decoration. Presently, Viscount Jellicoe and Her Excellency, Viscountess Jellicoe entered. Of course I was glad to meet "Jellicoe of Scapa Flow" Commander of the British Fleet. He is by no means a large man, but rather slim, with a nose large enough to make a rather square and determined chin seem a little weak at first glance. Her Excellency, Viscountess Jellicoe is a very handsome woman, entirely at home in her viceregal surroundings.

The guests arranged themselves in a semi-circle, the ladies to the right and gentlemen on the left. The Master of Ceremonies, one of the aides de camp, named each guest as the Governor reached him, or her, and His Excellency passed along the line with a handshake and word of greeting for each. He was immediately followed by Her Excellency, the Viscountess Jellicoe. The calling of the names enabled the gentlemen to identify the ladies assigned them, and the guests immediately passed into the dining saloon. I found the lady whom I escorted a very pleasing companion who showed real tact in coaching me regarding the etiquette of the occasion.

The Governor General sat at the middle of one side of the table which was beautifully decorated with flowers and which displayed much glittering cut-glass and silverware. The general conversation was much the same as would be heard in polite society everywhere and was often quite witty. One soldierly looking man near me had been on a lecturing tour in the United States, urging us to enter the war on the side of the Allies and he seemed greatly pleased with his experience. Uniformed attendants served the guests. There were about six courses accompanied by several kinds of wine which was indulged in with great moderation, and served mainly in the drinking of toasts. Lord Jellicoe proposed the usual toast to the King,—"The King, God bless him!" which was repeated in unison, all standing for the purpose. After we were seated the Governor General stood up again and proposed a toast to "The President of the United States" at which he saluted the only representative of that country present. All stood again and repeated the toast. I was, of course, immensely gratified by this token of good feeling. When the ladies left, the gentlemen remained to enjoy their cigars and wine. The man near me had just said, "Now let's have a good talk about America," when someone took me by the arm and said, "Come with me."

It was Lord Jellicoe himself who escorted me to a seat beside him and introduced me to the distinguished guests seated nearby, and then we chatted in a very friendly way about the United States. Among other things, he expressed great admiration, even affection for Admiral Sims, expressing the opinion that no better man could have been found to lead our navy "over there." He was also much interested in our method of selecting the Rhodes Scholars for Oxford, saying that he was chairman of the committee to select the scholars from New Zealand. It was evident that he wanted to show special courtesy to the representative of an American University. Taking me with him when we rejoined the ladies, he introduced me to several of them including "Her Excellency," as he called his wife, who chatted in a friendly way and showed me photographs of her children. We went to the billiard room where he showed me many hunting trophies, some very fine stags' heads among them. The party broke up about eleven P. M. and I was returned to my hotel after one of the unique experiences which sometimes come to an American professor in foreign lands, and much gratified that I had been made the vehicle through which was expressed the great desire of the Dominion Government to cultivate good feeling between New Zealand and the United States.

The next morning Mr. McDonald took me to the library, an excellent one under the direction of Mr. Anderson who was well up on the literature of early days in New Zealand and the folklore of the Maori. There were many valuable books concerning the early voyages to the South Seas, including those of Captain Cook, and a copy of part of his original log. There was also a very beautiful collection of greenstone, or jade, articles. We visited the manual training school where there is a group of quite good buildings but with rather inadequate equipment. I noted that most of the blackboard space was taken up with very good pictures in crayon.

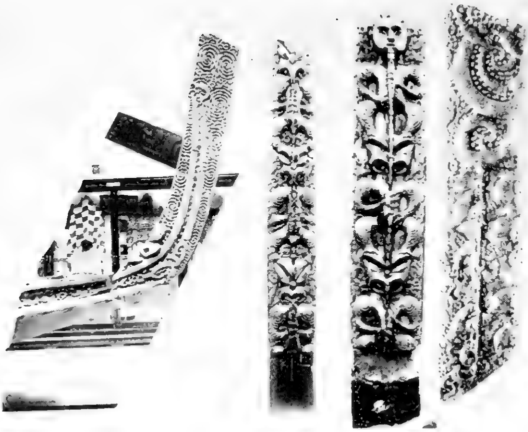
Much of the afternoon was spent in packing up for the visit to Christchurch which will be discussed in another chapter.

Returning to Wellington on the morning of August 10 I found that good staterooms had been reserved for our return trip to San Francisco on the S. S. Tahiti at a minimum rate on orders from headquarters. I also found that Stoner was not at all well and in charge of a doctor.

While calling on Mr. McDonald, I learned that he had ar-

Map of South Island, New Zealand

PLATE XLII



Illustrations of Maori wood carving
A very elaborate stern post for canoe (See page 244), two door-posts and a lintel (Photos by permission of H. Winkelmann, Auckland)
A fine lintel piece presented by the Dominion Museum, Wellington
Front of Maori house, a restoration (See page 183) (Photo reproduced by permission of H. Winkelmann, Auckland)

ranged for the Dominion Museum to present four living tuatara or sphenodons, to our University, and that I was to try to transport, alive, to Iowa City, probably the first living specimens to be taken to the interior of the United States. He also had arranged to present us with a large, elaborately carved Maori doorway and a number of other Maori articles which are now literally priceless, as it is illegal to purchase or export them except under permits from the Dominion Government. Exchange of publications was also arranged.

On learning of the very strict laws regarding the exportation of ethnological material, I had given up all hope of success in securing any for our museum, but found that when one goes to New Zealand with proper credentials, and succeeds in penetrating the somewhat rigid official crust, it is possible to secure many things which would be beyond the reach of the unofficial stranger. We owe this generous treatment very largely to our good friends, Mr. Hislop, Under Secretary for Internal Affiairs and Mr. McDonald, Acting Director of the Dominion Museum.

That evening Wylie and I took dinner with Mr. McDonald at his home in a beautiful suburb across the harbor. We spent a most delightful evening there, incidentally discovering that Mr. McDonald is an artist of real ability who has painted some remarkably fine life sized portraits in oil and has done some good etchings and sketches. Mrs. McDonald was very earnestly interested in prohibition and asked many questions regarding its success in the United States. They have a daughter who is anxious to visit America.

After returning to the hotel I spent a good deal of the night in revolving schemes for transporting the tuataras alive to the United States and in planning the final packing and shipment of our collection, which was considerably more extensive and valuable than I had anticipated.

The next day I found that Stoner was still sick and that Wylie, besides having a very bad cold, was threatened with sinus trouble which might become serious. This reduced our available force to about half the original number. Thomas and Glock were away on their long South Island trip and were not expected back until the day before sailing. Mrs. Stoner could help about the packing of the insects, but was mainly occupied with caring for her husband.

On August 12 Thomas and Glock returned. The Hon. Mr. G. M. Thompson, a prominent Government official, invited us to lunch in

Parliament House with the Speaker of the House, the Hon. Downie Stuart, Minister of Internal Affiairs, and about a dozen other members of Parliament and prominent officials. After an excellent lunch in a beautiful room in which the members were wont to take their noon-day meal, we were escorted over the Parliament Building, constructed of New Zealand marble of a rich gray tone mottled with white. The pillars were finely polished and quite imposing. We saw the Senate Chamber and the House of Representatives which were sumptuously furnished in native wood, finely carved.

We were allowed to go into the lobby (a very special favor) where the members gather for a game of billiards or other recreation, a comfortable and well warmed room in which to rest, then to the library used by the members. In the Council Room the walls and ceiling are beautifully finished with panels of selected woods, walnut and birdseye maple, presented by the Canadian Government in return for a similar donation from the New Zealand Government when the Canadian Parliament House was burned down.

We were then taken in autos to Mr. Hislop's for tea. His brother-in-law's estate is next to his, a tract of undisturbed native "bush" with enticing mossy and rocky paths wandering over the hills and crossing over little streams on rustic bridges. It must be a fairy-land in summer. The hospitality of Mr. and Mrs. Hislop is one of the brightest spots in our memories of New Zealand.

In the evening we went again to the Savage Club with Mr. Hislop where I was again asked to sit with the Chief Savage but I declined to inflict another speech. Thomas, however, spoke, and spoke well, making an excellent impression. The orchestra again rendered exceptionally fine music and we had two numbers by a celebrated violinist who was on a concert tour in New Zealand. We had made friends and I felt that the net results of our stay in Wellington were distinctly profitable to the University in the way of collections, literature and valuable connections with the officials and scientists of New Zealand.

I was much concerned over the ill-health of Stoner and Wylie and greatly dreaded that sailing day, only two days away, might find one or both of them too ill to embark, a calamity I had dreaded on all our expeditions but which we had thus far been spared.

On the morning of August 13 I called on both the invalids and found them better, much to my relief. That day was spent mainly in writing farewell letters and bringing my journal up to date. It was Sunday and no business could be transacted. Thomas and Glock came to my room in the evening and told of their wonderful experiences during nearly a month of travel over the greater part of New Zealand, including adventures on the glaciers of the New Zealand Alps and a description of the almost unmatched scenery in that wonder-land through which, as geologists, they had traveled back and forth for many hundreds of miles. Dr. Thomas will tell about this in another chapter.

On Monday August 14 I called at the Union Line Steamship office for mail but found none. We were told that it had probably been put on the Tahiti when she called at Wellington on her way to Australia and that were were likely to get it when we went aboard next day. We then went to the Museum and commenced packing our New Zealand collections, although the actual work was done largely by the museum men themselves, especially Mr. Hamilton, who had already been so efficient in aiding Dr. Stoner and others of our party. A fine lot of Maori things was laid out for us by Mr. McDonald. Several large pieces of elaborate carving, a number of stone adzes, a dancing dress, Maori coat, a death-mask showing the elaborate face carvings; which I believe, were carried to a greater extreme by the Maoris than by any other people; a model of a very elaborate door-frame, fish-hooks, sea shells, etc. These all were carefully packed in a huge box, and the work so well done that nothing was broken when the collection reached home.

I went with Mr. Hislop to say goodbye to the Governor General's Official Secretary, Mr. Day, who informed me that His Excellency requested a personal interview. Lord Jellicoe was very kindly in his greeting and we sat down and chatted for several minutes. He talked chiefly about the United States for which he expressed a very cordial feeling. He seemed much surprised that we had no distinct labor party in Congress such as had caused considerable trouble in England, Australia, and New Zealand. It was hard to realize that this quiet, unassuming gentleman had been one of the world figures in the great war, and I could not help thinking how we all held our breath in fearful suspense while he and the other British heroes fought the momentous battle of Jutland, driving back the great German fleet to remain sealed up until it was delivered to the victorious allies at Scapa Flow.

We also called on the Minister of Internal Affairs, Mr. Downie

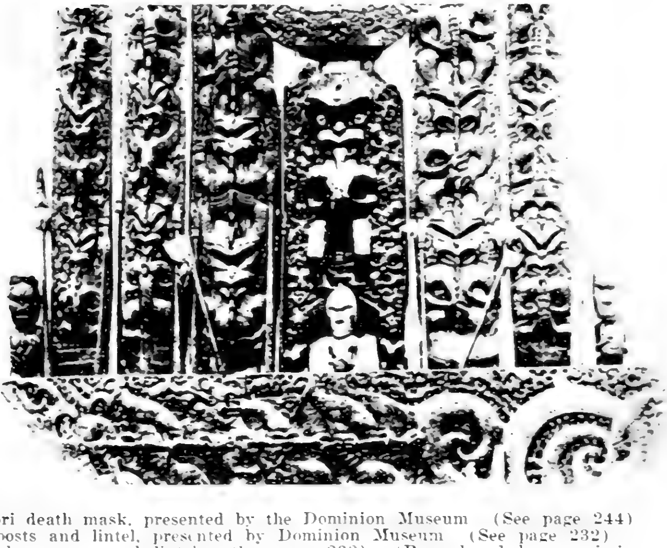
Stuart, but found him absent. On our way back to the Museum I had a good talk with Mr. Hislop who related some of his inimitable stories showing a keen appreciation of the humorous aspects of life.

This was the first rainy day we had experienced in Wellington. Stoner seemed slightly better, but quite weak and was not permitted to leave his room. Mr. Hamilton was so efficient in the packing that we could get along without Stoner who usually directed such work for the Expedition. Nine boxes of material were securely packed and plainly marked for their long homeward journey.

Mr. Best had very thoughtfully prepared a typewritten list of the things presented by the Dominion Museum with short descriptions of each article and this adds materially to the value of the donation.

That evening all of us but Stoner went to a farewell affair given by our good friends of Wellington. It was held in the Museum library room. Minister Stuart was good enough to preside and it seemed to me a fine tribute for him in his crippled condition and constant pain to honor us with his presence. He made a short speech full of good feeling and good wishes for the little party of scientists, whose visit he had done so much toward making a success. There were moving pictures of glaciers, geysers and other New Zealand marvels, native dances, fire-making with fire-sticks, incantations, eel festival, mat-weaving etc., directed by Mr. McDonald who gave a much appreciated touch of realism by showing a motion picture of a Maori girl weaving a chaplet of rushes and then, explaining that the young woman desired to give the chaplet to the only woman member of our party from the United States, handed a chaplet, identical in appearance to that just shown on the screen, to Mrs. Stoner.

A series of lantern slides were then shown, some by Mr. McDonald, animals and flowers by Mr. Oliver, and scenes from the Mawson Antarctic Expedition, of which he was a member, by Mr. Hamilton. An informal lunch served by the ladies was followed by farewell speeches. The Minister of Internal Affairs, Hon. Mr. Thompson, and others, showed hearty good will and appreciation of the value of our mission to New Zealand. In response Wylie, Thomas and I tried to tell them how grateful we were and how helpful their innumerable kindnesses had been. We tried also to show we were deeply sensible of the unbounded friendliness which



A Maori death mask, presented by the Dominion Museum (See page 244)
Door posts and lintel, presented by Dominion Museum (See page 232)
Door, door posts and lintel (See page 232) (Reproduced by permission of H. Winkelmann, Auckland)

PLATE XLIV

View in the Domain, Auckland (See page 256)
Albert Park, Auckland (See page 255)
Hot Springs at Rotorua (See page 258) (Photos by Stoner)

we had experienced at the hands of everyone with whom we had come in contact during our stay. This delightful evening was concluded by all joining hands and singing "Auld Lang Syne!" I confess that I was deeply affected by this leave-taking and never have been made to feel the sincere friendship of people of a foreign country more than we did on this memorable evening.

We greatly enjoyed our stay at Wellington and found much to admire there. Although somewhat smaller than Auckland, (it has a population of 103,000) it enjoys the advantage of being the capital of the Dominion and the center of governmental activities. There is evidently considerable rivalry between the two cities, as is quite natural, and commercial competition is keen. The two are equally metropolitan in appearance and the main business streets are lined with imposing buildings. Willis street is the Broadway of Wellington and here are found a number of banks, the main hotels and most of the large stores or shops. The Empire hotel seems to be the most dignified hostelry and is perhaps the best in New Zealand, at least the best that we saw.

The city is built mostly on low ground between the water front and the high ridge to the south. A cable tram-line climbs this hill from near the Lambton Quay to the region of the Botanical Gardens and Victoria College, affording easy access to some of the most beautiful suburbs of the city, while Observatory Hill crowns the summit from which a superb bird's-eye view of the city and wharfs is attained. Still further to the east is Island Bay with a fine motor road, the Esplanade, running along the coast for miles. Government building is said to be one of the largest modern wooden buildings in the world. The most imposing public building is Parliament building which has already been described, while Government House is to the east of the main business center. There is a good tram-car system, of which the main line runs along the water front and out Willis street. But the thing which impressed us most was the healthy, vigorous, ruddy-cheeked children one meets everywhere in New Zealand. In spite of the fact that their knees were bare and often seemed blue with cold, I belive that nowhere else have I seen so good an average of strong, vigorous looking boys and girls. These children struck me as being the very best product of all the good products of New Zealand.

The city has an extensive series of wharves excellently equipped in every way, especially in the matter of powerful cranes to handle the cargoes of incoming and outgoing vessels from almost every part of the world. There are ferries which run to Christchurch, Nelson, and several other ports, and these boats seemed to be filled with passengers. Indeed, the water-front gives the impression of greater activity than that of Auckland and the business blocks and public buildings are quite up-to-date and impressive.

Victoria College, one of the four which make up the University, is built of brick, with stone trimmings and is four stories in height. It would be called a good college building anywhere. The biological laboratories are well equipped and seem to be well manned. The educational system of New Zealand is built on the model of that of the mother country in general, but seems to be modified so as to give good educational facilities to all classes of people and to have more of a leaning toward a practical or vocational preparation for life, with less emphasis on purely academic courses. Education is free for the most part, and those who have to work during the day are provided for by night courses in the University Colleges. The more capable students secure scholarships which yield free tuition. Education, moreover, is very generally compulsory. The four University Colleges are located at Auckland, Wellington, Christchurch and Dunedin.

New Zealand has its fair share of eminent scientific men and a number of them have been and are research men of the highest grade. The best zoölogical textbook I know is Parker & Haswell's Zoölogy. The senior author is a New Zealand man.

There are several first class newspapers, but we were usually too busy to read them. They followed the English fashion of printing the advertisements on the first pages and the news items afterwards. I have before me a copy of the Auckland Weekly News, printed on September 21, 1922, and it would be a credit to enterprising journalism anywhere in the world. There are 84 pages, 18½ by 12 inches in size. The first ten pages are occupied by advertising matter. The first page of news is filled by an account of "Prohibition in America," written by a clergyman who is a violent anti-prohibitionist and holds forth on the "dire consequences" of the prohibition law in the United States. It is full of vitriolic propaganda which would characterize the ravings of the "Bootleggers' Federation" in America. Being placed on one of the advertising pages it may have been published at advertising rates. The excitement about prohibition at that time was largely due to the impending visit of "Pussy-foot Johnson" to New Zealand which certainly aroused a wild rage among those interested in the liquor business either as producers or consumers. After the advertising section came "The Weekly News Magazine" with instalments of several novels; then the general news items, a health column, literature and art, notes and comments, New Zealand news, and a page devoted to Wellington. What follows appears to be editorial matter, the leader being "A Call to Service" anent the threatening war with Turkey for which Australia and New Zealand offered assistance even to the extent of sending troops. One page is devoted largely to proceedings in Parliament and another to miscellaneous items. Auckland occupies two pages, then follow several pages of cabled items, largely from London and other parts of the British Empire, with a few brief items from New York. The latest news under the heading, "Second Edition," occupies two pages, followed by another page of advertisements.

The most conspicuous feature, however, is sixteen full pages of extraordinarily beautiful reproductions of photographs, as good as can be found anywhere, devoted to Wellington and its environment, printed on heavy, glazed paper, giving various panoramic views of the city, the wharves, water front, bird's-eye view of the main business district from an aeroplane, the Parliament building, public buildings and colleges, principal streets, three panoramic views of the city and harbor, the zoölogical garden, picturesque spots in and about Wellington, City Officials, a golf championship meet, Wellington's milk supply and a page devoted to racing and a Rugby match between New South Wales and Auckland. Several pages are devoted to commercial news, miscellaneous items, sports, agriculture and farming, stock raising etc., and finally, ten pages more of advertising matter. Certainly a comprehensive bill of fare to interest all classes of readers. There are a number of good dailies in the more important centers. The Government Publicity Agent, Mr. Drew, edits and apparently censors all news regarding Dominion official affairs.

I found the reporters alert and evidently "on the job" as in other places but it seemed that they were less given to distorting the sayings of interviewed parties and to be more conscientiously accurate in their stories. The doings of high government officials and personages of various sorts occupy much less space in the public press than in England or even the United States, which is evidence of a nearer approach to real democracy.

CHAPTER XIV

A TRIP TO CHRISTCHURCH

On the evening of August 3 I took the ferry to Christchurch, South Island, a twelve hour run. The boat was fairly comfortable but much crowded on account of race week. I talked with a man who had been through the Gallipoli Campaign, who said that their most terrible experience was caused by the countless swarms of flies, getting into one's eyes, ears, nose and mouth and taken with almost every mouthful of food. He believed that the Anzacs had been forced to undertake an absolutely impossible thing; that the Turkish defensive positions were actually impregnable without heavy artillery and that Australian and New Zealand men were needlessly sacrificed.

I slept fairly well in spite of a rough sea and the vociferous sea-sickness of several of my neighbors.

It was bitterly cold on deck in the morning in spite of the brilliant sunshine. The long range of the Southern Alps stretched along the entire western horizon, more deeply and completely buried in dazzling white snow than any other mountains I have seen; the wind sweeping down from those masses of snow and ice chilled one to the very bone.

A good and abundant breakfast was served on board. There is a frank friendliness about these Colonials in sharp contrast to the frigidity of the Englishman and his reluctance to make acquaintance with strangers, and there is much less formality than with us under similar circumstances.

We reached Lyttelton, the port of Christchurch, about ten o'clock in the morning. Our train was waiting on the wharf, but was so crowded that I was unable to secure a seat and had to stand up all the way. It seems that the law against over-crowding passenger cars is not enforced during race week. The trip was only about twenty minutes long, however. Shortly after starting we passed through a fairly large tunnel in which the coal smoke from the engine was actually stifling. We emerged into a flat country, the Canterbury Plains, extending for 150 miles between the mountains and the coast, probably the largest uninterrupted level area in New Zealand, a magnificent country for agriculture, particularly stock-raising, for here the famous Canterbury mutton is produced.

The St. Elmo hotel where I had reserved a room was not a single building but a group of seven rather small frame houses, one of which contained the office and dining room. I had difficulty in securing a suitable room although I had telegraphed in advance. The one first assigned me was in the house furthest removed from the dining-room and without heat of any sort. Of course everything was filled on account of the races; but I had specified a room with heat and insisted on getting it. As a result I finally secured a front room next to the house where meals were served and with a real fireplace for which I gladly paid 3 shillings extra per day.

I met Thomas and Glock returning from their grand tour of South Island, but only for a very few minutes before they took their train for Dunedin, farther south. They were both well and had had wonderful experiences during their thousand mile trip through South Island. Its magnificent scenery, including a thrilling adventure on a great glacier, will be related elsewhere.

A reporter from the Lyttelton paper had been notified by Mr. McDonald of my intended visit and was on hand for an interview as soon as I reached Christchurch. The resulting interview was quite correctly reported.

After lunch I took a stroll to the Canterbury Museum which I had been told was the best in New Zealand. It is a dignified stone building after the style of English university architecture and was much more substantial than the Dominion Museum at Wellington and larger than the one at Auckland. There was a good exhibit of Antarctic birds and mammals, including many from Sir Douglas Mawson's Expedition, such as the snowy petrel, Emperor penguins, Ross' seal and crab-eating seal; all were well mounted in an appropriate habitat group. There was also a good collection of mammal skeletons containing representatives of most of the families from various parts of the world. Like all other public buildings here, the museum was unheated and I soon became chilled through so did not linger to inspect the rest of the exhibits.

I called on Dr. Chilton, Rector of Canterbury College, one of the four university colleges of New Zealand. He is among the ablest naturalists in New Zealand and a recognized authority.

particularly in certain groups of marine arthropods, the world over. He lives in a good stone house conforming in architecture to the other college buildings, the whole reminding one of the solid buildings of an English university. The reception room was large, very well furnished and was warmed by a cheerful wood fire-place. I also had the pleasure of meeting Mrs. Chilton, a very pleasant motherly sort of lady who must be a great favorite with the college boys. Here as everywhere else the shadow of the great war is evident and the Chiltons had lost a son on the battle front.

Christchurch is a city of about 110,000 population, and no city in Old England is more English than this. It is the center of the great Canterbury Plains and has the River Avon meandering through it. It differs widely from the other New Zealand cities I visited in that its streets run regularly at right angles with each other, especially those away from the main business center; the out-lying districts look much like our prairie cities. The business blocks have all the solidity of a European metropolis and the Cathedral is one of the most imposing and architecturally satisfying structures which I saw in the Dominion. The streets are broad and well paved, with running water from the mountains in all the gutters, thus reminding one of Salt Lake City.

On Saturday, August 5, I had the pleasure of meeting Mr. Archey, of the museum, a splendidly set up young fellow of the finest English type to whom I owe very much of the pleasure and profit of my visit to Christchurch. He took me over the museum and pointed out some of its high lights. There is a good, systematic collection of New Zealand birds, several of which are now extinct. There is a complete skeleton of a small species of moa which is particularly interesting, its leg-bones being extraordinarily heavy and massive in comparison with the remainder of the skeleton. The largest moa, constructed of matched bones from several specimens of approximately equal size, is twelve feet high.

Mr. Archey thinks that the eagle was an important factor in the extermination of this gigantic bird, as it preyed on the helpless young whose uncouth parents had no effective means of defending it. Another important factor was undoubtedly the native Maori race. There is no trace of wings on any of the skeletons which I saw, and it seems that we have here one of the very few actually wingless birds which have been discovered, although I believe that at least one specimen of moa has been found with rudimentary wings.

There is a skeleton of an eighty-five foot whale in a shed outside of the museum proper, and they are making a cast of a ten-foot swordfish. The Gangetic dolphin is another strange form exhibited here, and a good mounted skeleton of the elephant seal is of much interest.

The birds are much better specimens of taxidermist's art than the mammals and do credit to the skill of the preparator. An intersting group of penguins is very well executed and includes both young and old of Adele and Emperor besides some other species donated by the National Antarctic Expedition. Most of the mounted mammals are old and represent taxidermic methods now out of date. Besides they are badly faded.

The ethnological exhibit is probably the best part of the museum and I saw in New Zealand none more extensive although it is not the largest so far as Maori things are concerned. It is well arranged and displayed in well lighted rooms. The oriental material is particularly well illustrated and reflects much credit on those in charge of the museum. I understand that the geological and mineralogical collections are especially fine.

As this is the last of the three large museums which I visited in New Zealand, it may not be out of place to add a few notes regarding them. It should be said, however, that there are other museums which are reported to be of at least equal importance, particularly that of the Otago University at Dunedin, which I did not see, much to my regret.

In my opinion the best of the three is that at Auckland, the only one which is a municipal affair. Great credit is certainly due Mr. Cheeseman, for many years the Curator, and evidently a man of almost infinite industry and patience. He has succeeded in getting together a collection of Maori art and industries which will probably never be duplicated, as the few remaining artists are fast passing away. Mr. Cheeseman very wisely devoted his efforts to the collecting and preservation of all things relating to the natives of New Zealand who lived mainly on North Island and there reached their highest cultural level; and so the venerable Curator has gathered together full series of specimens illustrating in a most comprehensive way a culture which is unique and full of human interest. I think I have never seen a better display of the ethnography of a strictly localized people whose history and achievements seem unique among the natives of the great realm of the South Pacific and whose art far surpasses all others developed by any native Polynesian people. Almost every phase of the life and achievements of the Maoris is there to be studied by any one who comes properly accredited. Not only the vast array of specimens, very carefully labeled and excellently installed, are at the disposal of the student, but he has at hand the resources of an excellent library where he can consult literary sources concerning the early history of the country and the publications of a host of previous workers. The most accomplished and up-to-date museum man in New Zeland, in my opinion, was Mr. T. L. Griffin, the assistant curator of the Auckland Museum, who has had the best training and experience and is extraordinarily versatile in his tastes and achievements. His habitat group of the kiwi, spotted shag, etc., and his restoration of the moa are real works of genius which compare favorably with those of the most able taxidermists anywhere. His artistic ability is shown in its perfection by the large series of New Zealand fishes mounted after the most modern technique and colored with a fidelity and delicacy of touch which is admirable,—as good as I have seen anywhere, and their poses are remarkably life-like. The fishes, be it remembered, are about the most difficult of all the vertebrates to preserve in anything like a satisfactory manner and present, perhaps, the severest test of the ability of the preparator. It is to be sincerely hoped that the Dominion Government will properly recognize the masterly work of Mr. Griffin and sustain him in it.

The Dominion Museum at Wellington is in good hands under the care of Mr. J. McDonald, Acting Director. He also is an excellent artist, a man of exceptional ability and resource with an intimate acquaintance with the Maori and is an expert photographer. He is ably assisted by Mr. Hamilton, Mr. Oliver and others, all good in their respective departments.

One of the best assets of this museum is Mr. Elsdon Best, whose knowledge of the Maori people is probably more profound than that of any other living man. He is a veteran in the work but seems as alert and keen as any of the many scientists we met. Practically his whole life has been devoted to an understanding of the Maoris and their work. He lived with them for many years studied their language, habits, art and traditions until he is said to know more of that fast disappearing language and folk-lore than does any one native at the present time. His industry has been tremendous, and his scientific publications make a surprisingly long list. He has also prepared for publication some extensive monographs, the manuscript of which I saw and which, when published, will be a monument to his industry and learning. He impresses me as being a man of the very first rank among the scientists of New Zealand.

This museum is badly handicapped by the building in which it is housed, a wooden structure altogether unworthy of its contents and a potential fire-trap. It makes cold chills run down one's back to think of what will happen in case of a conflagration, and experience warns us that such a disaster is almost inevitable in course of time. In case of fire, the life work of some of New Zealand's foremost scientists will be wiped out and the Dominion Government will suffer a serious loss. The whole building is so crowded with almost priceless collections that very little could be saved in such an emergency.

The Director of this museum, Mr. J. Allen Thomson, F.G.S., is an outstanding man of science, being for many years a most prolific investigator, who has published a great many valuable papers on geological and ethnological subjects. He was, unfortunately, ill at the time of our visit and we therefore failed to meet him, much to our loss and regret. He is the son of the member of Parliament who gave the lunch in Parliament Building at which we were the guests of honor.

The Dominion Museum should be the best in New Zealand as it has the backing of the Government; but it is impossible to pass on its real merits on account of the crowded condition of its collections and the practical inaccessibility of much of the material. We can only hope that this state of affairs is but temporary and that it will have a home appropriately spacious, safe and dignified before disaster overtakes it. The scientific productivity of its staff is sufficient proof that the collections are well used, and that the material is by no means lying idle.

Of the Canterbury Museum it may be said that it has the best building and the most extensive ethnological collection, including much Maori work of great interest and value. Its moa remains are of special interest and seem to include a greater number of species of that giant bird than we saw elsewhere. It also exhibits the largest series of mammalian skeletons and mounted specimens. Most of the latter, however, are in poor condition, although the latter accessions, both of mammals and birds, are fully up to modern standards. I understand that since our visit it has acquired some notable collections, especially in the ornithological line. It seems that the very rigid legal restrictions regarding the collecting of birds has worked a hardship both here and at Auckland.

In order that the Otago University Museum at Dunedin may not pass without comment because of my inability to visit it, I will add the following quotation from an account by H. D. Skinner[1]:

"The Otago University Museum. The foundation of the present collections of the Museum of the University of Otago was laid by Dr. Hector (afterwards Sir James Hector, F.R.S.) who organized a large and excellent natural history collection for the New Zealand Exhibition held in Dunedin in 1865. This collection formed the basis of the present museum collections, but it was not until 1877 that the central block of the present buildings was completed and opened, the first curator being Captain F. W. Hutton (afterward Professor Hutton, F.R.S.) Professor Hutton was succeeded by Professor T. J. Parker, F.R.S., under whose direction some of the most striking exhibits were added. Notable among these is the series of elasmobranch skeletons not surpassed in any museum in the world. The method by which they were prepared was worked out by Professor Parker and Edwin Jennings, museum taxidermist.

"A notable benefaction was the gift of Dr. T. M. Hocken in 1907 of his great collection of books, manuscripts and pictures relating to early New Zealand and the Pacific, and his large ethnographic collection. The Hocken collection includes the largest series in existence of manuscripts relating to the settlement of New Zealand.

"The zoological collections are extensive, being especially strong in New Zealand birds and their eggs, in New Zealand fishes, and in the invertebrates. Of special interest is the series of extinct birds, the collection of moa remains being very extensive, and including eggs, feathers, skin and foot-prints as well as the largest number of individual skeletons in any museum.

"Perhaps the most notable exhibit here is the material from the moa hunter's camp at the mouth of the Shag River, which ilustrates the stage of culture reached by the earliest inhabitants of the southern district. Their culture would seem, on the whole,

[1] New Zealand Nature Notes for the Use of Members of the Australian Association for the Advancement of Science, Wellington Meeting, January, 1923.

higher than that of the tribes found in occupation at the beginning of the Nineteenth Century.''

All of these museums are distinctly creditable institutions and all have an out-put of research results which is above the average, it seems to me, of museums of similar size and resources in the United States.

Dr. Chilton, Rector of Canterbury College, took me through the buildings of that institution which reminded me of those at Oxford, though on a much smaller scale. The laboratories are well equipped and Dr. Chilton's own collection of Crustacea is quite extensive, for he is an acknowledged authority in certain groups. I found that college work, even that of the registrar, was suspended every afternoon during race week, thus I did not meet many of the professors. The whole establishment is distinctly English in the best traditional sense of the word, and the atmosphere is that of cultural rather than vocational training.

The students are as healthy and manly a set of young boys as one would see anywhere. Over the level Canterbury Plains, resembling our own western prairies, many of the boys rode bicycles to and from the college, which again reminds one of English universities; but their bare knees and heads in the cold winter weather certainly gave one the shivers although custom has doubtless hardened them to the exposure. They gave the impression that the Colonials are keeping up the good old stock in a most satisfactory manner. I saw remarkably little evidence of anæmic conditions and was particularly impressed by the fact that impaired eyesight was rare among them, if absence of glasses was a reliable indication.

The University of New Zealand comprises four University Colleges, each of which specializes in definite fields. The one at Dunedin devotes itself to mining, medicine, dental, veterinary and domestic science; the one at Christchurch focuses its work on engineering and technical science; that at Wellington on law and science; while the college at Auckland is concerned mainly with commerce and mining. The total registration in the four institutions was 4,123 in 1921 and they cost the Government £117,434.

There is also an exceptionally well endowed agricultural college at Lincoln as well as industrial schools and schools for the deaf, feeble minded and blind.

The relation of birth-rate to death-rate is always a criterion of the prosperity of a people and in this respect New Zealand makes a particularly good showing. The death-rate in 1921 was 8.73 per thousand, while the birth-rate for the same year was 23.34 per thousand; that is, the birth-rate was two and one-half times as great as the death-rate. When one sees the remarkably fine sturdy children it becomes evident that the population is being replaced by children of superior grade and in satisfactory numbers. At this rate of increase the country will soon be adequately populated with a stock as purely British and of the same superb qualities as are exhibited by the present generation. Indeed, from a purely biological standpoint, that of eugenics, I doubt if any country has a better prospect before it than has New Zealand.

I very greatly enjoyed a visit to the estate of Mr. Stead, one of the leading ornithologists of the country. Indeed, I was told that he knew more about the birds of the Dominion than any other living authority. His place is at Islam, Islam Road, one of the suburbs of Christchurch. After leaving the tram, the walk was delightful. Islam Road is hemmed in in places by very high hedges trimmed so as to form a perpendicular wall of green foliage, even in winter. Some of these hedges must have been at least twelve feet high, and they shut out the view of the grounds beyond with true English exclusiveness. Arriving at a gate with a sign "Islam," I walked along a winding driveway among the trees, many of which were pine, interspersed with beautiful shrubbery. The house, evidently the home of wealth and refinement, soon came into view and I was greeted very pleasantly by Mr. Stead, my host, who is a comparatively young, athletic-looking man who, for a wonder, neither drank nor smoked, the latter being quite an exceptional thing among New Zealanders. There was another guest, a Mr. Wilson, who evidently had a good scientific and practical knowledge of botany and ornithology, and who seemed to be a man of culture and abundant means.

We strolled through the charming gardens before going in to lunch, and these were so beautiful even in winter that one can well imagine their charm in summer time. It seems to me that they afford an excellent model of landscape gardening, with a clear meandering trout stream harboring many interesting aquatic plants, and thickets which furnished a delightful retreat for the numerous bird friends of our host. He was a typical, out-door naturalist who knew the intimate ways and manners of the woodland birds, some of which he brought near by imitating their own calls. There were many rhododendrons, not in bloom at this time, which doubtless make a noble display in summer. Mr. Stead pointed out a kind of miniature water-lily that was in bloom and entirely new to me; it had a long, smooth leaf and a deep, vase-like blossom, white with many conspicuous black stamens arranged in a circle inside.

At lunch we met Mrs. Stead, a very charming hostess, who presided with the easy dignity which makes English hospitality so pleasing wherever it is encountered. After lunch Mr. Stead showed us the treasures of his New Zealand bird collection, the most complete one which I saw in the Dominion. He pointed out the curious fact that many New Zealand birds were characterized by a marked fluffiness about the feathers of the rump. He showed a species of duck in which the young female had the plumage of a male and afterward took on the proper dress of the mature female; the only case of the kind I have seen. There was a fine series of kiwi skins illustrating the several species of this strange wingless form, many yellow-wattled and blue-wattled "crows," parrots, parakeets, etc., in fact, a nearly complete collection of the birds of New Zealand, all in the best of condition and arranged in suitable trays that slid into metal boxes where they would be safe from insect pests.

Mr. Stead remarked that if an arrangement for exchange with the museum could be made, he would add some of his own specimens to the series sent to Iowa. Later on he took me in his auto to the tram-car which quickly returned me to my hotel in time for afternoon tea with Dr. and Mrs. Chilton. Here was another home of the finest type of culture such as one finds among the Oxford University instructors.

August 7 was cold and clear and I took a walk, with my camera, through part of the city. There is a noble monument to Captain Scott, the Antarctic explorer who lost his life after reaching the South Pole. It stands with a background of willow trees near the banks of the river Avon and is a very well executed portrait statue in white marble showing the noted explorer in his polar costume. At night a search-light is turned on the monument with very fine effect, making it stand out sharply against the dark background of trees.

All of the more important Antarctic explorers are well known here as most of them made Lyttelton, the port of Christchurch, their point of departure for the unknown region of the Antarctic.

I heard many stories of Shackleton, Mawson, Amundsen and Scott, from citizens who knew these men personally. One of these stories related to the cause of the tragic ending of Scott's last expedition and revealed one of the real reasons for its failure. I do not feel at liberty to give the entire story as it was told to me, presumably, in confidence; but it indicated that Captain Scott died through a chivalrous determination to keep his promise that a certain one of his party should accompany him to the South Pole in spite of the solemn warning of New Zealand friends that this man would break down under the strain and wreck the whole expedition. That man did go to the pole and did break down and had to be hauled by his weary companions on the long terrible return trip, thus delaying the party until death finally overtook them when one more day's journey would have brought them to their base of supplies.

At the Canterbury Museum I had the pleasure of making the acquaintance of Professor Robert Speight, the curator, and an accomplished naturalist. We discussed the matter of exchanging specimens, particularly bird skins. He was quite willing to arrange for such an exchange but said that permission must be secured from the Dominion Government through Mr. Hislop. It seems to be the feeling here that the Government favors the Dominion Museum at Wellington in such matters, and that the other institutions are badly handicapped on account of legal restrictions which hinder and often prevent exchanges with foreign institutions. Professor Speight authorized Mr. Archey to put aside a series of bird skins for exchange with the museum of the State University of Iowa, provided authorization could be secured from the Dominion officials. This attempt evidently failed as I was informed after returning home that on account of legal restrictions it was impractical to carry out our plans.

That evening I enjoyed the hospitality of Mr. Archey's home and found the same warm-hearted friendliness which seems characteristic of British Colonials wherever I have been. He has a wife and two children and his wife's parents. Mr. McGee, Mrs. Archey's father, assured me that every British and Colonial child was taught in school that America was right when she went into the Revolutionary War against England.

The next day I enjoyed an all-day outing with Mr. Archey. We started at nine on a jaunt to Port Hills overlooking Lyttelton Harbor. We took a tram-car across the outskirts of Christchurch which with its modern looking wooden houses spread over a relatively flat plain resembles a town in our mid-western states. We began to climb a hillside dotted with picturesque houses, set in groups in the valleys and cozy nooks of the hill-side. As we climbed still higher the range of southern Alps with their snowy peaks loomed far off on the western horizon. They were perhaps fifty miles distant across the great Canterbury Plains, one of the richest agricultural regions in New Zealand, stretching away until they appeared blue like the ocean in the far distance. Near at hand and directly before us as we looked back over the route by which we came, the whole of Christchurch was spread out, giving a wonderful bird's-eye view of the plan of the city with its regular streets breaking it up into squares like those of a checker-board. The contrast between the regularity of this city and the maze of irregular streets in Auckland and Wellington could hardly be more striking, illustrating as it does the effect of topography on the building plan.

Christchurch is by no means as picturesque as either of the other cities visited but it is certainly much more convenient. There is no natural limit to its growth as there is in the case of Wellington, surrounded by high hills, many of which are quite rugged and abrupt. Christchurch does not lack picturesque sites for suburban homes, however, for the snug little valleys, ravines and rounded hills on the slope of one of which we stood, furnish innumerable places for houses high enough to escape the heat in summer, and command exquisite vistas of city, plain and the majesty of distant snow-clad peaks. The scene must be lovely in summer when the farms are green with growing crops. We walked along a good road of easy grade with patches of fir trees here and there, and the yellow bloom of gorse splotching the hills gave a lively bit of color to relieve the grays and dull olive of the hills. The gorse, by the way, is a noxious weed in parts of New Zealand and is regarded with about as much affection as the dandelion is with us. The hills have few trees and are largely clothed with thick tussocks of tall grass which furnish excellent pasturage for sheep. In one valley were hundreds of rabbit burrows, and these pestiferous rodents are as great a nuisance here as in Australia, but are coming fairly under control in the more densely populated districts.

Presently we came to the top of a divide and could look over into a part of Lyttelton harbor, but the town itself could not be seen. The harbor is surrounded by high hills and is almost completely land-locked, making the port of Lyttelton one of the best in New Zealand. The region is entirely volcanic and the harbor a submerged valley, perhaps an old crater. Seen from the height on which we stood the sea was intensely blue and the shadows of clouds flecking the hills afforded a constant shifting of light and shade.

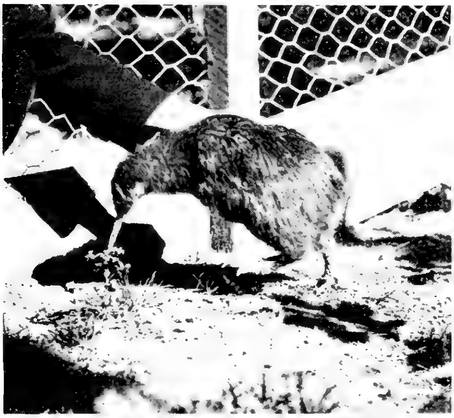
We took tea at eleven o'clock at an exceedingly picturesque wayside inn called the "Kiwi," as announced by a swinging signboard with a representation of that unique bird. It was just such a delightful wayside retreat as one meets so frequently in out-of-the-way parts of England. Later we strolled on further and I took a few photographs of the hills and harbor. Returning to the Kiwi we had an excellent lunch and rested awhile as we enjoyed the view, before strolling leisurely downward for about three miles, I should judge, until we reached the tram line again. Mr. Archey proved a most delightful companion. Indeed it seems to me that the English and British Colonials never appear to better advantage than in the course of such a stroll. Walking and talking has been reduced to a fine art by their university men, and one can hardly realize how extremely enjoyable a day's walk may be until he takes it with such a companion. We chatted on things biological, about which he is well versed, of things political, social, college life here and in America, and finally of course, on the World War, in which he had borne a part on the battle line in France. In looking back over the various acquaintances formed in New Zealand I can not remember meeting a single man of army age who had not done his bit "over there." No man able to go seems to have occupied a swivel chair at home during the great conflict.

England was certainly justified in her children and no one who has spent much time in her overseas possessions from 1914 to 1922 could fail to be immensely impressed by the solidarity of the British Empire. Mr. Archey said that, for him, the hardest thing to bear was the deadly monotony of the time spent in the trenches between the brief periods of intense activity when they went "over the top" or repelled attacks. This walk over the breezy Port Hills and the panoramic views from the top will remain as one of the high lights of my many delightful experiences in New Zealand.

After supper Dr. Chilton called and we had a cozy chat in

Mamaku bush, near Rotorua (See page 259)
Mr. Harold Hamilton (left) and Mr. C. T. Griffin, F.R.Z. (See pages 252 and 257)
Decaying remu log where *Peripatus* was found (See page 276) (Photos by Stoner)

PLATE XLVI



Aquarium at Wellington (See page 264)
A live Kiwi or *Apteryx* (See page 272)
The Kea or flesh-eating parrot (See page 269) (Photos by Stoner)

front of my fire-place. He is a most genial man and has had many notable experiences. He very kindly presented me with the splendid two volume monograph, "The Sub-Antarctic Islands of New Zealand," of which he is editor. It is a fine piece of bookmanking, containing many beautiful plates, some of which are colored. These remote and uninhabited islands are of extreme scientific interest, although even their names are unknown to most people. Those included in the work referred to are all to the south and southeast of New Zealand and include the Snares, the Auckland Island group, Campbell Island, Antipodes Islands, Bounty Islands and the Macquarie Islands. The last lie some six hundred miles to the southeast of New Zealand, in latitude 57° south and so are well within the Antarctic area, as are most of the others. They are also notable as the home of the elephant seal, an animal of exceptional interest to zoologists. The Snares, the Auckland group and Campbell Islands are also the home of the southern fur-seal which is said still to be quite numerous. The fur-seal proper, *Arctocephalus forsteri,* although at one time threatened with extermination, now seems to be increasing. They are at present found on the Snares, Bounties and the western coast of South Island.

The expedition of which these volumes form the report was sent out in 1907 by the Dominion Government at the request of a number of scientific societies, prominent among which were the Philosophical Institute of Canterbury and the Otago Institute. As I had made the acquaintance of several members of the expedition, i.e., Dr. Cockayne, Professor Speight, Professor Kirk and Dr. Chilton, the "Sub-Antarctic Islands of New Zealand" is a work of personal as well as scientific interest to me and constitutes one of the real treasures of my book-shelves. It is published by the Philosophical Institute of Canterbury and is a credit to all concerned in its production.

On August 10 I bade good-bye to my Christchurch friends after enjoying lunch with Professor Speight and Mr. Archey, took the afternoon train to Lyttelton, which was reached after dark, and went immediately on board the ferry for Wellington which sailed almost at once.

That evening, while seated in the smoking room of the ferry, a man, whom I took to be a jockey returning from the races after a successful race week, sat down beside me. Without consulting me he ordered two whiskeys and sodas and handed one to me.

He seemed utterly unable to comprehend how any sane man could refuse a drink, but compromised by drinking them both himself. Then he ordered whiskeys and sodas by couples and drank them all himself until he was wrapped in slumber by my side.

The sea was smoother than on the down trip and I slept well, had a good breakfast on board in the morning and enjoyed the superb view of Wellington harbor as we steamed toward the docks just as "the rosy fingered daughter of the morn" appeared and the rising sun pierced the mists of the morning to glorify the surrounding hills.

CHAPTER XV

THE MAORIS OF NEW ZEALAND[1]

No thinking person can visit New Zealand without becoming immensely interested in its aboriginal people, the Maoris. My acquaintance with the natives themselves is almost nil, as my work did not take me to those parts of North Island where they still live in considerable numbers. Although a good many were seen about Auckland and Wellington, they did not wear their native costumes, as did the Fijians, and their European clothes were by no means pictureseque. They looked very much like the civilized Indians in our country.

But in the museums we visited, the mass of literature published by the Dominion government, particularly the Dominion Museum, by the New Zealand Institute and other scientific organizations, and most of all conversation with Mr. Elsdon Best, Mr. J. McDonald and many other well informed Colonials, offered abundant material from which reliable information regarding the Maoris was to be obtained.

It seems certain that these people are descendants from pure Polynesian stock, quite different from that of the Fijians who are very largely Melanesian in derivation. The Maoris are stalwart people with rather light brown skin and hair which is straight, compared with the Fijians. Many of them wear full beards, especially the older men, and the shape of the head and general physiognomy are strongly Caucasian in appearance. Practically all authorities give them a high intellectual rating and the history of their dealings with the white men and the official positions which some of them occupy, amply confirm this conclusion. They represent but a fractional minority of the population of New

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[1] To Mr. Elsdon Best of the Dominion Museum I am indebted for most of the information contained in this chapter. Some of it was gleaned from conversations with that eminent ethnologist and some from his writings. The mistakes which will doubtless be found are to be attributed exclusively to the writer either from faulty recollections of conversation or from misinterpretation of published statements. A relatively small proportion of this chapter is gleaned from "Romance of History, New Zealand," by Reginald Horsley, published by Frederick A. Stokes Company, New York. This work is written in popular style, and may be an illustration of poetic license and not strictly scientific in its accuracy.

Zealand and seem finally to have settled down into a peaceful and law abiding folk, although they gave trouble enough in the early days.

When the first white explorers reached New Zealand they found tattooing, or rather face carving, carried to greater elaboration than anywhere else in the world, perhaps. Not a square half-inch of the face was unmarked and the cheeks, forehead, nose and chin were covered with deeply incised lines of most intricate designs, the spiral motif predominating. We were told that every line had its exact significance and that any departure from the prescribed patterns was a most serious offense. These deep lines were literally chiseled into the face with a chisel-like instrument and mallet. The accompanying photograph of a death-mask of a Maori chief given us by the Dominion Museum tells the story better than any written description.

One shudders at the thought of the slow, lengthened torture borne by these men in being tattooed in order to impress the beholder with the rank and dignity of these old chiefs. The ceremony partook of a religious nature and was in conformity with a rigid ritual. The man operated on could touch no food with his hands during the long period while the artist was at work, but was fed by an attendant. A blue pigment was inserted into each incision to make the pattern stand out more prominently producing a most hideous and terrifying effect. Few living Maoris show this face marking in its perfection and the custom has almost entirely died out although even yet one occasionally sees a face with a few indistinct blue lines. But the carving on wood exhibits real art brought to a beauty and perfection scarcely to be excelled anywhere. Before the introduction of metal tools it must have required almost infinite patience and many years to turn out a masterpiece. I was told, for instance, that one of the elaborately carved stern-posts of their great war canoes employed several generations of artists before the design was completed and that much of the work was done after the canoe was launched. Now the original design must have existed in the mind of the one who commenced the work, as the finished product shows perfect unity of plan throughout. Moreover, the colors of the lower surface of the projecting eaves of their elaborately ornamented *whare whakairo,* or meeting house, are in patterns of very pleasing and graceful designs in red, black and white.

Mr. Best informed me that the spiral designs are not found elsewhere in Polynesia. Moreover, it seems impossible that such a motif could arise independently after the Maoris reached New Zealand. He is inclined to think it due to the pre-Maori race, or "Moriori," a people leaving little positive material evidence of their existence, but probably originating in Melanesia, where the spiral design is known to occur.

The Maoris were a war-like race and cannibalism was common among them, as throughout most of Polynesia. They showed real military genius in planning their "pas" or fortified places which were strategically located and surrounded by well designed stockades, moats and trenches which were ample protection against spears, clubs or stones. Of course they were never intended to withstand artillery fire of which these people learned to their grief when they resisted the Colonial Government.

Like the Fijians, these people believed in a literal immortality; moreover they had a highly elaborate system of spiritual and mental concepts as set forth in Mr. Best's little work on "Spiritual and Mental Concepts of the Maoris," but the subject is too complicated for treatment here.[2]

The word "Maori" is used throughout the most of Polynesia to designate simply natives or aborigines, I was told that a New Zealand Maori can understand the language of either the Cook or Society Island group, and this is the best of evidence of community of origin.

It seems that about forty generations ago two Polynesian chiefs discovered New Zealand and returned to the islands whence they came, and that some twelve generations later the first real settlers arrived in New Zealand. In the interval the Moriori or pre-Maoris appeared, probably from Melanesia, and were in New Zealand when the first migration of the true Maori arrived.

The land from whence they came is known by well established tradition as Hawaiki and there is still some doubt as to its location, but there is much strong evidence, I understand, to indicate

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[2] In this connection, mention should be made of a series of monographs of the Dominion Museum, published in compact, convenient form and containing a mine of interesting, reliable information. The three published before we left New Zealand, copies of which are before me, are:

No. 1. "Some Aspects of Maori Myth and Religion" By Elsdon Best
No. 2. "Spiritual and Mental Concepts of the Maori" By Elsdon Best
No. 3 "Astronomical Knowledge of the Maori" By Elsdon Best

These "Dominion Museum Monographs" are published by the Museum, Wellington, under the authority of the Minister of Internal Affairs.

that it was Rarotonga or other islands of the Cook group; or possibly Tahiti of the Society Islands.

These old Polynesians were experienced navigators and accustomed to long voyages, with a good knowledge of the currents, winds, seasons and stars. They were as bold and fearless as the old Vikings. Their great canoes, many of them double, were thoroughly sea-worthy and very well built, although without nails or iron in any shape. The labor involved in their construction was tremendous when we remember that only stone implements were used. Long experience had given a good practical knowledge of the proper lines for speed and safety.

Mr. Best, in his "Astronomical Knowledge of the Maori," says: "In pre-European times the stars were studied by the natives—not by all persons, be it explained, but by a limited number of men of the *tohunga* (or adept) class, who devoted much time to the study of the *ra rorika,* or little suns, as they were termed. Such men would often pass long hours of the night in contemplating the stars, and would be looked upon as reliable weather prophets. Travelers and fishermen would consult them ere venturing forth, and their powers are also said to have enabled them to foretell the general aspect of coming seasons, their fruitfulness or otherwise. Such were the studies of the *tohunga kokorangi,* the Maori astronomer.

"These men knew well the movements of the stars; they knew when to look for their appearance, and always waited it in order to scan closely their aspect. One famous old wise man of the Wairarapa district of last century, devoted much of his time to studying the stars and planets. His contemporaries have told me that they have often known him to pass the greater part of the night on the summit of a hillock near his hut gazing continuously at the heavens—surely his thoughts would return to the old seafaring ancestors who followed the stars across half a world, who sailed eastward and northward and southward until they lost the familiar stars of long centuries, and saw strange new ones appear above the far-off horizon, and then, further back his memory would recall the teachings of his elders concerning the hidden fatherlands, the mist enshrouded land of Irihia, wherein his ancestors had dwelt ere the gleaming stars lured them forth on the great trackless ocean that was to be their home for so many centuries."

The story of the discovery of New Zealand by the people from

Hawaiki, and its later colonization is an epic worthy of a Homer. As related below, I have used the sources mentioned at the beginning of this chapter, but find that these disagree as to the interval between the first discovery "about forty generations ago" by two chiefs and their followers; and as to the exodus of some thousand men, women and children in ten or twelve double canoes.

Mr. Best thinks that there was an interval of some twelve generations between the two, while Stokes, in his "New Zealand," represents the exodus as having been led by the discoverers who first visited the new land, and on returning to Hawaiki organized the emigration of their friends who became the ancestors of the present Maori of New Zealand.

I will adopt for my purpose the view of Mr. Best, whose authority on all matters concerning the Maoris and their traditions is hardly to be questioned.

Before Columbus sailed on his famous voyage to discover a New World, a certain tribe, probably in Rarotonga, found itself conquered in war and in danger of extermination. In desperation they counseled as to how to escape utter destruction, and one heroic chief proposed to his friend that they sail away in their big canoes, or two of them lashed together, into the vast unknown of the South Pacific, away to the West and South in the path of the setting sun. The annual migrations of certain birds, notably the godwit, suggested that there was an unknown land in that direction, but no one knew how many hundreds or thousands of miles away.

So this small band of adventurers said good-bye to their families and friends and set their course in the path of the setting sun. Long study and the experience gained in numerous shorter voyages had made them familiar with the steady trade winds of that ocean world, and they knew much about the stars and their courses.

Day after day they sailed over the blue sea; or, the wind failing, took to their paddles and plodded wearily onward. The days multiplied into weeks, perhaps months. They suffered hunger and thirst, heat by day and cold by night as the Southern Cross rose steadily towards the zenith in the heavens. Their boats were simply two big canoes lashed together, entirely shelterless from the rain-squalls and blinding spray in stormy weather. Hope long deferred had sickened their hearts as, reduced almost to skeletons, they plied their paddles and the scoop-shaped bailers.

At last they sighted land, a veritable paradise it must have seemed, and found a harbor free from the pounding surf. And this was the first landing in New Zealand by the men now known as Maoris or aborigines of that new world!

They found nature bountiful beyond their fondest hopes. Mighty forests of kauri from which hundred-man canoes could be built, strange edible plants, flowers, cold pure water from the lofty mountains, edible ferns and tubers, fish, oysters, crabs and other sea foods. They found flax from which serviceable garments could be woven, wonderful greenstone from which weapons and ornaments could be fashioned. Gigantic wingless birds were there, twice as high as man, helpless and too inexperienced to be shy, with flesh sufficient to feast a score of men. They found another but smaller bird, the kiwi, also wingless, whose close-set thatch of feathers furnished warm clothes; mutton birds with much fat for winter consumption, and fur seals with coats warm enough for the bitterest cold of of the antipodes.

After partly exploring this El Dorado of the South the adventurers again took council together and said, "This wonderful land which we have discovered is of little avail to us unless women and children of our own race can share it and help us develop our new world and found a new nation in peace." What we have done can be done again! We will return to Hawaiki our native land, get such of our tribe as are still alive, with their household treasures, and bring them with us to this, our new home."

So they repaired their big canoes, embarked again with samples of the riches of the new land, and set their faces once more to the wide expanse of the South Pacific, utilizing the trade wind which, with the changing season, was now favorable on the opposite course and again steadily at their backs. With the genius of born navigators, helped by the winds, the stars, the sun and the currents they actually retraced their course of nearly three thousand miles, and found the remnant of their people which through some marvelous Providence had escaped extermination. As men risen from the dead they were received with rejoicing, which was turned to amazement when they told their story and exhibited the samples from their new world. Slowly incredulity turned to belief.

Generations passed and the exploit of this Maori Columbus and his friends lingered only as a tradition; but finally from some cause which is not made plain by the authorities I have consulted, a much larger number of descendants of the original explorers and their friends and relatives decided to abandon their home in Hawaiki and found a new race in the land so vividly described by the returning wanderers of some twelve generations before. Even former enemies were induced to join them in the great adventure.

Their canoes, sixty or eighty feet long, hollowed out of mighty logs, their sides elevated by ponderous sideboards, thwarts skillfully bound in with sennit, sails of closely woven mats, ropes of fibers from their native plants and painted with iron oxide mixed with shark's oil, were carefully overhauled.

And so from Rarotonga and neighboring islands a noble fleet of perhaps a dozen double canoes able to accommodate a thousand persons assembled for the great migration from Hawaiki. In them they placed their women and children, seeds and roots of their most valued plants, coconut, taro and yam, berries, edible gourds and plantain; wild fowl and dogs, their only animal food in those days, perhaps even the island rats to eke out the supply.

At last all was ready; sacrifices had been made to propitiate their gods, and strange incantations by their medicine men had revealed the omens favorable to success. Surely the like of this migration can hardly be duplicated in all history, an undertaking of unparalleled audacity which resulted in the birth of a nation!

Each canoe had one, sometimes two, professional star-gazers to lend the aid of their knowledge of navigation. It is said that they knew and had names for at least three hundred stars, and used them to mark the seasons and to guide them over the trackless waste of the broad South Seas.

Again following the path of the setting sun, which at that season was southwest, by day, and the stars and familiar constellations by night, this epoch-making odyssey passed over the loneliest sea on earth. (We passed over the same track and saw but one lone ship during the whole voyage!) A few flying-fish sprang up now and then before the on-rushing prows of the canoes; now and then a shark, or perhaps a school of porpoises accompanied them; now and then a lonely albatross, or a few petrels. The tropic clouds hung low on the horizon by day, and the splendor of the southern stars hung over them by night. There were many days of steady calm which gives the Pacific its name, a few, perhaps of storm with mighty billows thundering up from the Antarctic, home of the wildest seas in all the world!

These people were but savages according to our notions, cannibals according to tradition; but they were men of splendid bodies, unsurpassed bravery, abounding faith in themselves and their gods, risking all that they held dear in this one heroic adventure that they might find a home in a hitherto unpeopled land. What a theme for the inspired poet and painter is this! A story unsurpassed, it seems to me, in all that stirs the blood and inflames the imagination!

At last, reduced almost to utter starvation, exhausted to the limit of human endurance, they landed in the home of their dreams and took possession of the promised land.

All Maoris trace their lineage to one or other of the great canoes whose names are to them what the Mayflower is to the New Englander. Each family has a "genealogical stick" with prominent projections on one side, each of which stands for a generation. Every true Maori can name his forefathers as represented by the projections, beginning with his own father and going back as many as twenty-six generations, ending with the name of a great canoe, one of the brave fleet which sailed away from Hawaiki some six hundred years before.

The immigrants prospered in this new world, the original settlers separated, each family or clan having abundant choice of location, and spread over a good portion of North Island; later they crossed Cook's Strait to South Island. As the clans grew stronger they came into conflict with each other and war arose with pillage and reprisal. They quickly overcame the weaker Moriori whom they encountered here and there and reduced them to servitude although they seem to have intermarried freely.

Thus they lived and multiplied for several centuries, and developed the surprising art which was in abundant evidence when the first whites came to New Zealand, an art which amazes every visitor to the museums in the New Zealand of the present.

It seems that Abel Tasman was the first European to reach this country, arriving in 1642. He anchored near Tasman Bay in the west coast of South Island where the town of Nelson is now, but he appears to have sailed away without landing. It was not until 127 years later that the famous navigator, Captain Cook, anchored in Poverty Bay, North Island. The natives, however, were suspicious and his attempts to establish contact with them met with no success. He then spent some six months in surveying the entire coast of both North and South Island, and met the natives on various occasions, learning a good deal about them, as a perusal of his published narrative shows. He gave them some pigs which ran wild and increased rapidly in numbers, thus providing a valuable meat supply. He also introduced the potato, turnip, cabbage and other useful vegetables and fruits. In 1779 Captain Cook revisited New Zealand, when some of his men got into trouble with the Maoris and killed a number of them, but friendly relations seemed afterwards to have been established. He doubtless could have conquered the whole country by allying himself with some of the more powerful chiefs, but refrained on humanitarian grounds.

There followed a period in which the French attempted to obtain control of this great prize of the South Seas. One of the first of these was Captain Marion du Fresne who, with a number of his men, was treacherously murdered by the Maoris, for which his Lieutenant Crozet inflicted a terrible reprisal, killing a large number of the natives. This misadventure resulted in the French giving up their designs against New Zealand for a time at least.

Ever since the visit of Captain Cook, British whalers had occasionally visited the country. Early in the nineteenth century trade was established between them and the natives, and this resulted in scattered settlements, often founded by the rough and ready sailors of the time. Quarrels, massacres and reprisals marked the history of the early adventurers.

Later came Samuel Marsdan, a missionary, followed by a number of others who, in spite of enormous difficulties, did much to pave the way for a better understanding between the white settlers and the Maoris. By the Peace of 1814 the British obtained recognition of rights of sovereignty in New Zealand.

At one time a ghastly trade in human heads preserved by a sort of smoking process by which they were permanently mummified, was quite flourishing and doubtless was responsible for numerous murders among the Maoris.

The main cause for much of the trouble between the whites and the natives was a mutual misunderstanding regarding the transfer of land. The Maoris, is seems, regarded it as almost unthinkable that they should actually sell their land, and when the whites claimed a purchase the Maoris declared that they had only leased the land to the settlers. It was a long time before these differences were finally adjusted. At one time a tract of forty thousand acres was said to have been purchased from the natives for thirty-six axes![3]

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[3] See "New Zealand" by Reginald Horsley, p. 123.

Various schemes for extensive colonization were attempted, but it was not until 1840 that a British governor proclaimed the sovereignty of Queen Victoria over the whole of New Zealand, which was regarded as a sort of dependency administered by the government of Australia. In 1841, however, New Zealand was declared an Independent Colony, and in 1907, by proclamation of King Edward, its status became that of a Dominion.

At present theree are 52,751 Maoris (including half-castes) in New Zealand. Unlike the Fijians they have shown little reluctance about racial admixture with the whites and I was told that there are now very few if any who can claim to be of absolutely pure Maori stock. Hence the race is becoming rapidly assimilated and thus will not be destroyed, but absorbed; a fate surely preferable to extinction which threatens so many of the Polynesian peoples. A number of the Colonials now have more or less Maori blood and are not ashamed of their descent.

Although there have been prolonged wars between the Maoris and the colonists in the past, it seems that a good many of the native tribes were not hostile to the whites, and it is doubtful if there were more than half of them at war with the colonials at any one time. Indeed a considerable portion of them sided with the conquering race on each occasion when war was waged.

Maori political status seems quite satisfactory at present as they are given the ballot and have their own representative in Parliament. Indeed the Hon. Sir M. Pomare, apparently a full-blooded Maori and a strikingly handsome man, is a member of the Executive Council of New Zealand and representative of the native race. This is in accord with the universal practice in the British Colonial possessions and seems to work well. Of course here as elsewhere there have been grievous injustices and sometimes cruelties, in times past, but present relations between the races are entire amicable. There seems to be little of the sharp color line so much emphasized between the black and white races in the United States and so the intermixture of Maoris and whites goes on almost insensibly with little of the unfortunate effect which we associate with the idea. The fact that the Maoris do not wear their original native garb, except for picture post-card purposes, also helps to do away with racial antipathies. The two peoples seem to enter with enthusiasm into the matter of athletic sports, one of the strong points with the British the world over.

During race week while I was at Christchurch there were several serious accidents, although I heard of no fatal results.

Aquatic sports also attract much attention, especially in the summer time. Canoe races are said to be very spirited events and the canoe hurdle races are particular exciting. This race involves the taking of the canoes over a hurdle in the shape of a log lying across the course and requires great skill and agility such as delights the active and athletic Maoris. The men run the prow of their canoe as far up on the smooth log or spar as possible, then leap out on the hurdle, drag the canoe over, jump in and paddle away. Of course there are a good many spills which only add to the fun.

Occasionally the Maoris at Rotorua in the thermal region indulge in a "Haki" or old-time dance in native costume, which consists of a dancing skirt reaching from waist to knee. It seems originally to have been a war dance with much brandishing of spears and clubs and loud yelling.

The Governor General, Lord Jellicoe, has greatly enhanced his popularity by his democratic interest in various forms of sport, and mixes freely with his people much to his enjoyment and their satisfaction.

CHAPTER XVI

ORNITHOLOGICAL AND ENTOMOLOGICAL EXPERIENCES IN NEW ZEALAND

By Dayton Stoner

Our exodus from tropical Fiji occurred on July 3. After four days on a storm-tossed sea aboard the R. M. S. Makura, where I experienced all the horrible (I believe they are never fatal) vicissitudes of *mal-de-mer,* due, in part, to what I termed the "Makura-wiggle," we arrived in the quiet waters of Auckland Harbor, New Zealand, at 4:00 P. M. July 7. After medical inspection and certain other formalities which are always associated with leaving ship, we made our way to lodgings which had been arranged for us in Auckland, a considerable part of which is made up of suburbs meandering between and around hills and old volcanic craters. More than fifty of the latter are in the immediate vicinity.

Shortly after our arrival in Auckland, through the kindness of Mr. T. E. Cheeseman, Curator of the Auckland Institute and Museum, and his assistant, Mr. L. T. Griffin, our party was given laboratory space and working quarters as well as library facilities. These courtesies greatly aided our efforts during the three weeks we were in the city. To Mr. Griffin, in particular, I am indebted for many helpful suggestions, for specimens, and for enthusiastic coöperation in other ways.

Also, in addition to the persons specifically mentioned in the succeeding pages, I am under obligation to the following for assistance in one way or another: Mr. Cleland, caretaker at the Auckland Institute and Museum; Mr. W. H. Cobbledick, Forest Service Department, Rotorua; Mr. R. Falla, Devonport; Professor H. B. Kirk, Wellington; Mr. A. W. B. Powell, Auckland; and Mr. D. Miller, Department of Agriculture, Wellington. To Professor H. F. Wickham of the State University of Iowa, I am indebted for the determination of certain beetles mentioned in this paper.

With Auckland as a base, excursions were made to various localities for the purpose of collecting birds and insects. In the heart of the city itself, the well-kept Albert Park, with its beautiful landscape gardens, offered opportunity for ornithological observation and we often went there to take advantage of the warm sunshine and to see the birds.

At one side of the park is a large cement building which houses the excellent library, with reading rooms, lending and childrens' departments making available its more than 50,000 volumes. The building is inadequately warmed, a single small electric heater affording the warmth for the large reading room; many of the patrons were sitting in their great-coats.

One wing of this building is given over to a display of paintings in oil and water-colors, as well as of documents and articles which have historic interest and value so far as New Zealand is concerned. An unusually fine collection of oil paintings depicting Maori life and famous Maoris is exhibited. One in particular, shows the departure of six outrigger sailing canoes from Rarotonga; another of the series shows a sick and half-starved member of this band of bold sailors sighting the shores of New Zealand from one of the canoes, thus conveying the impression to the observer that the Maoris originally came from Rarotonga.

In the vicinity of Auckland are numerous small volcanic islands on some of which ancient craters, though long since inactive, remain more or less extant. On July 13, through the courtesy of the Auckland Harbor Board and as guests of the city engineer, Mr. Povey, some of the members of our party enjoyed a launch trip to one of these craters, Mt. Rangitoto, about twelve miles from the city. The island mountain is over 900 feet high. Volcanic scoria is everywhere, old lava flows crumpled and twisted and thrown about make walking difficult. The vegetation is sparse, hard and stunted and of a xerophytic nature; it is but slightly rooted in the small amount of loose soil on the surface and between the lava blocks. Pohutukawas flourish better than any other tree. Neither birds nor insects are plentiful. Of the former only a few white-eyes and fantails greeted us. Opossums, rabbits and wallabies have been introduced from Australia and appear to thrive. At the side of the trail I came sufficiently close to one of these wallabies (*Petrogale penicillata*) to secure a photograph at fifteen feet.

At the summit of the crater, a magnificent view of Auckland, Auckland Harbor, Hauraki Gulf and the island of Moto Tapu was displayed before us. The old crater itself, two hundred feet deep, with precipitous, bracken-covered sides and a very symmetrical rim almost a half-mile in circumference, gave evidence of the mighty upheaval which had occurred in past ages. It was very cold and windy at the summit and we did not tarry there long.

Near Auckland one of the most interesting places in which to collect insects was a hilly preserve of 217 acres known as "The Domain" in which both native and introduced trees abound. Among the latter are many oaks whose fallen leaves covered the ground thickly. But for the green native trees and tree ferns we might have thought ourselves enjoying the late October days in Iowa. Numerous trails lead here and there through the harsh grasses. Rotten logs and stumps offer retreat for many kinds of insects. The ground is always moist in the denser parts of the preserve.

Another day I visited Mt. Eden and One Tree Hill, two volcanic craters near Auckland; both are maintained as preserves. The former is about five hundred feet high and from its summit a fine view of the city, harbor and surroundings is presented. Its very symmetrical crater is about five hundred feet across, one hundred fifty feet deep, and the grassy sides are very steep. We climbed and slid down into this ancient pit, the bottom of which is covered with scoria and "bombs," some of which we overturned in search of terrestrial arthropods; millipedes, centipedes and spiders were common.

One Tree Hill, some two miles away, bears on its crest not a single tree as its name suggests, but *five* trees. A series of broad grassy terraces leads to the summit from which an excellent view of the surrounding country may be obtained. Here also is buried the donor of this preserve, Sir John Logan Campbell, who died June 22, 1912. His grave is covered by a marble slab and surrounded by an iron fence. Although the crater is larger than the one at Mt. Eden it is not so symmetrical. At one side, a deep flat valley leads away from it as if the ancient lava flow might have occurred there.

Never have I seen earth phenomena better illustrated than in these two huge craters and their surroundings; terraces, valleys, slight depressions, great flat tables, scoria, bombs,—all give evidence of the mighty activities of vulcanism.

Triangulation stations have been ereectd on the summits of many of these old craters.

Still another point of interest and a place where we found good collecting was Kauri Gully, a forest preserve of sixty acres, across the bay from Auckland, near Northcote, one of its suburbs. The region is very hilly. An exceedingly profuse growth of vegetation excludes sunlight in many places, and in such shaded situations the ground is continually moist. Tree ferns and bracken grow luxuriantly; conifers and hardwoods are common; here we saw some fine examples of the famous New Zealand kauri trees. Indeed, the home of the kauri is a little farther north in the Auckland Provincial District. A beautiful clear stream flows through the Gully and offers suitable habitats for various kinds of aquatic and semi-aquatic insects and other forms of animal life.

Onehunga, a suburb of Auckland, forty-five minutes by tram from the heart of the city, lies at the head of Manukau Harbor on the west coast. North Island at this point is but a mile in width. Extensive beaches and mud flats here offer suitable habitats for many kinds of shore birds. On our return to Auckland by tram I was interested in a placard which I saw advertising for sale a bit of real estate; it had a distinctly ornithological tone and read as follows: "This lot for sale: See Gosling and Fowler."

A trip on the government-owned narrow gauge railroad to Helensville, thirty-eight miles north of Auckland, proved profitable. The hot sulphur springs located there are attractive to those afflicted with rheumatism and kindred ailments. Much of the country is low, boggy grazing land. We saw many fine herds of dairy cattle, and coöperative creameries seem to flourish in the region. Birds which are more characteristic of open country are found here, such as the New Zealand quail and pipit; it was here also that I first encountered the far-famed European skylark which has been introduced into the Dominion.

Previous to our arrival in the Dominion we had made an effort to secure a Government permit to collect birds for the Zoological Museum at the University of Iowa; however, owing to the unusually rigorous and strictly enforced laws relating to the protection and conservation of New Zealand birds, considerable difficulty was experienced in obtaining official permission to take them. After some correspondence with the Minister of Internal Affairs, the matter of granting a permit was delegated to the Dominion Museum at Wellington through whose offices a perfectly amicable and satisfactory arrangement was consummated. While I personally was never actually given a permit to kill birds, the Dominion Museum sent one of its staff, Mr. Harold Hamilton, who was furnished with such a document, to accompany me wherever I might wish to go and to assist me in taking, with a few restrictions, whatever birds I desired. This was a most generous and gracious concession and I found Mr. Hamilton a very enjoyable and skillful field companion; a large measure of whatever success came to me in collecting birds during the two weeks that we spent together was due to his efforts.

Before undertaking any active collecting it was necessary to register my shotgun, an Iver Johnson, 410 gauge, No. 85921, Fitchburg, Mass., with the police in Auckland. Incidentally I may say that this little gun most happily surprised me with its excellent shooting qualities.

After about three weeks in and about Auckland, Mrs. Stoner, Mr. Hamilton and I boarded the train for Rotorua, in the heart of the thermal district, 170 miles to the southeast. Rotorua, a town of some two thousand inhabitants, exclusive of the tourists, is principally a summer resort famous for the curative properties of its hot springs and mud baths, most of which are under government supervision. It is one thousand feet above sea level and we found the temperature even lower here than at Auckland; the lowest record during our stay of four days was 18° F. Some of the baths bear peculiar and more or less attractive names; before leaving the region I enjoyed a plunge in the "Duchess" bath, which at a temperature of 99° F. gave me a most comfortable even though fleeting feeling of warmth.

Immediately upon his arrival at Rotorua the visitor is greeted by evidences of thermal and volcanic activity. Strong sulphurous fumes are particularly noticeable and from time to time various areas toward the outskirts of the town are enshrouded by escaping steam from the hot springs. All the streets are paved with a fine white volcanic ash. The minute particles are very irritating to one's eyes as they are blown about by the winds.

From Rotorua as a base we made two exceedingly productive side trips to collect birds and insects. Through the courtesy of Mr. D. W. Morehouse, the Government Fish Agent, who tendered the use of his six-cylinder Buick touring car, we were able to visit Lake Roto Ehu twenty-three miles northeast of Rotorua. A rough and tortuous road led us through the villages of Tikitere and Roto Iti to some fine native bush known as Hongi's Track at the south end of Lake Roto Iti. Most of the trees are remu, thickly intertwined with the tough, pliant stems of supple-jack. En route we passed boiling springs and hot lakes; several times we stopped to look for birds and insects; at one halt we shot a bell bird which was feeding on the reddish-brown berries of a shrubby tree (*Panax* sp.). In the dense bush, fantails were common and very tame, allowing one to approach within three or four feet of them. Small flocks of tuias or parson-birds were seen in the tops of the tall trees. Tomtits, silver-eyes and gray warblers were fairly common. A shot was taken at a morepork owl but the bird escaped.

The Mamaku bush, seventeen miles northwest of Rotorua by rail, and 1885 feet above sea level, afforded the best example I saw of a typical New Zealand forest. Magnificent miro, tawa and remu trees, many of them over a hundred feet high and covered with mosses and lichens, were being cut down by expert choppers. Remu wood is much in demand for building purposes in the colony, and tawa proves to be valuable for butter boxes since it imparts no odor to the butter.

After a tree is felled, one or two men trim it up and cut away the surrounding small trees and brush. The huge log is then "snaked out" to the logging train a half-mile away by a donkey-engine. Considerable ingenuity is demanded on the part of the woodsmen in meeting new situations which arise in dragging out the logs. It is unfortunate that so much of the finest woods in the Dominion is being thus sacrificed to commercial enterprise.

Naturally, one expects to find birds plentiful in such a region. Silver-eyes, white-heads, tomtits and fantails are abundant and tame. Mr. Hamilton captured one silver-eye in his hand. Our best finds of the day were a wood pigeon and the rare North Island robin.

Toward the northwest side of Rotorua, and facing Lake Rotorua, is the picturesque native village of Ohinemutu. Here, a great deal of the old Maori life survives. Most of the houses are painted red and have galvanized iron roofs. Many of the lintels, cornices and fronts of the houses are elaborately carved with the characteristic scroll-like figures so common in Maori art.

Two fine examples of Maori handiwork are the historic meeting house, Tama-te-Kapua, and the near-by artistic and partly reconstructed Anglican church with its surrounding burial ground. At the meeting house a native "Tangi" was going on. After a death has occurred in a family it is the custom among the Maoris for the friends and relatives of the deceased to congregate for a period of mutual condolence and sorrow, expressed by loud wailing and moaning; sometimes these tangis last for several hours, the mourners sitting or standing as they choose; after a longer or shorter period of mourning a feast takes place. This particular tangi was well under way when we entered the village; it continued during our stay of over an hour and lasted for I know not how long after our departure. We found that it was being held in honor of some relative who had died more than a year previously.

At numerous places in the village hot and boiling water continually issues from the ground and flows into Lake Rotorua. The Maoris have taken advantage of some of these boiling pools and have placed boxes and barrels in the sand around them; by covering these over with gunny sacks or tarpaulins, natural steam cookers are had right at their doors. Here and there at the margins of the hot pools may be seen the unmistakable signs of feathers from domestic fowls; plucking and broiling are accomplished at the same cooker.

Another tribe of Maoris lives at the village of Whakarewarewa, locally known as "Whaka," two miles south of Rotorua. Here also mist, steam and sulphurous fumes fill the air; mud geysers, smoke-pots and paint-pots contribute to the malodorous condition of the region. Great geysers formerly played here, one of them to a height of 1500 feet, but only their miniatures now remain to perform to a height of ten or fifteen feet. Some of the geysers have been "soaped to death," great quantities of soap having been poured into them at one time and another, to force them to play on special occasions.

Remnants of the old geysers, notable among which was Wairoa geyser, now consist solely of great white or pinkish terraces discolored by the sulphurous fumes which issue from the boiling and gurgling waters far beneath. In some places the rocks are hot while two feet away they may be cold. It would be interesting, although perhaps somewhat alarming, to know what is taking place in the earth under Whaka.

One evening we attended a Maori concert of twenty numbers made up largely of singing and dancing supervised by Guide Georgina, one of the twin sisters whom we had met the day before at Whaka where they were acting as guides. Both these women had been in San Francisco at the time of the World's Fair there; they could speak English fairly well and when not dressed in native costume could wear the silk dresses and high-heeled shoes of

America and Europe with as good grace as any belle of either country.

The dancing was done by both men and women in native costume and consisted of the ''Haka'' or war dance with some variations. The performance was accompanied by queer facial grimaces and much yelling. The graceful ''Poi dance'' was performed entirely by women to the accompaniment of vocal and instrumental music. The pois are ovate bags about three inches in diameter and covered with the bark of raupo, a kind of native reed or rush. The dancers hold a poi in each hand by a plaited raupo cord and tap them together or against the back or palm of the hand in time to the music. Encores were freely given even though the theatre was very cold and we sat in blankets and overcoats.

Our schedule called for departure from Rotorua on the afternoon of July 31 and, accordingly, we booked passage for Wellington, 275 miles to the south, on the New Zealand Government Railways.

These railroads are narrow-gauge with small but very powerful engines which draw express trains from Auckland to Wellington, a distance of 426 miles, in sixteen hours. New Zealand railroad crossings bear the sign, ''Look out for the Engine,'' which is, it seems to me, more appropriate than our own well-known warning legend. Both first class and second class accommodations may be had. First class fare is a little more than four cents per mile. The carriages are fairly comfortable but are cold in winter since they lack proper heating facilities. Accessory heating appliances in the form of rectangular metal containers for sodium salycilate which have been warmed by immersion in boiling water are distributed in the carriages farthest from the engine.

The names of the stations are not called and passengers know of their arrival at the proper destination only from the huge yellow-lettered signs on the station platforms. About eleven o'clock the train stops at some station where passengers as well as train hands indulge in morning tea; afternoon tea may be had at the proper time as well. Good food is to be obtained at certain stations along the line from a well organized system of restaurants.

The sleeping carriages are divided into compartments with two or four berths placed crosswise in the car; mattresses are not furnished. On cold nights the porter comes through the train making inquiry as to the number of passengers who wish hot water-bottles for additional warmth.

Many of the experiences on the trip were new to us but they afforded a good idea of certain habits and customs of the people and we should have missed much without them.

Wellington, the capital of the Dominion, is a lively city where the homes of more than 90,000 people are distributed over the steep hills that encircle the harbor. These windy heights rising from five to six hundred feet above the sea have earned for the city the sobriquet, "Windy Wellington." The deep and almost completely land-locked harbor is visited by ocean-going steamers more frequently than any other in the Colony. Great ocean liners can dock within three hundred yards of the General Post Office.

One of the finest buildings in Wellington and one of which New Zealand is justly proud is the new, steam-heated Parliament Building constructed of New Zealand marble. It occupies a commanding position near the business part of the city. We were privileged, on several occasions, to attend sessions of the House, and to hear discussions not unlike those which occur in our own House of Representatives at Washington, D.C.

Shortly after our arrival in Wellington, Mrs. Stoner and I found satisfactory lodgings at Caulfield House, a select boarding house near the Parliament Building. A number of the members of Parliament resided there while that legislative body was in session, and it was our privilege to enjoy the acquaintance of some of them.

One of the interesting persons whom we met at this place was Mr. Hector Macquarrie, the author of "Tahiti Days." Mr. Macquarrie was in New Zealand for the purpose of securing material and local color for another volume.

Through the courtesy of the Acting Director of the Dominion Museum, Mr. J. McDonald, laboratory and desk space were given our party in that building. Besides Mr. Hamilton, several other members of the museum staff aided me by giving suggestions, advice, and in collecting specimens. Not the least of Mr. Hamilton's efforts were directed toward conveying me to collecting grounds and other places of interest on his American-made "Indian" motorcycle equipped with side-car.

Mrs. Stoner and I spent two weeks in Wellington but I was able to occupy only half the time to advantage owing to illness. However, before I was compelled to take to my bed with an attack of jaundice, superinduced by a hard cold which I contracted just a week before we were to sail from New Zealand, I enjoyed several collecting and observation trips to points about the city and surrounding country.

One day, in company with Messrs. J. G. Myers and E. H. Atkinson of the Government Biological Laboratory, Mr. W. R. B. Oliver of the Dominion Museum and Professor Wylie, I visited the "rain forest" in Gollins Valley.

After a heavy up-hill climb from the beach at Rona Bay, we descended into the Valley, following a little stream. The ground was wet and muddy. Again, remu, tawa, rata, beech and tree ferns predominated. Birds were not so plentiful as in the bush farther north, although for the most part, the same species were represented. Mt. Marshall, fifteen miles away, could be made out as it reared its snow-capped peak fifteen thousand feet above sea level.

One of the most enjoyable trips which I made from Wellington included a visit to the well-kept zoölogical park.

"A twenty-five minute ride on the tramcar through Newtown brings one to the zoological park, a preserve of seventy and one-half acres where the natural conditions have been modified as little as is consistent with the safe keeping of the many forms of animal life contained therein. Trees, flowers and miscellaneous vegetation, streams and ponds and other natural topographic features, even the hills themselves, are utilized to the greatest degree in working out the arrangement and construction of dens, paddocks and other details connected with the proper housing of the animals.

"Ponds have been constructed for the aquatic birds and mammals; hilly fields have been enclosed for the Himalayan goats, Indian swamp buffalo and other ungulates; cages have been built along the banks for lions, tigers and other carnivors; the ever-attractive monkey and bird houses are set in the open near the entrance to the park and away from the trees where the sun may reach them.

"The park is maintained partly through taxation and partly through fees which are collected at the gate on certain days; on other days admissioin to the park is free. Numerous helpers are employed and a curator, skilled in the handling and care of mammals, birds and reptiles is in constant attendance.

"Naturally enough, many Australian species of birds and marsupials are on exhibition. One of the finest appearing and liveliest members of the lot, a dingo or wild dog was offered me by

Mr. Langdridge, the keeper, if I would pay its transportation to America. Unfortunately I was obliged to refuse the proffered gift.

"One of the most interesting features of the park is a series of eighteen terraria and aquaria which have been built into one side of a hill, walled completely over with brick and fitted with glass fronts so that the occupants may be viewed by the frequent visitors at this popular resort. Here are exhibited many kinds of fish and some turtles and lizards. Among the latter are two living tuataras. These animals form a link between the ancient saurians and modern reptiles and are the only species in the order. They are indigenous to New Zealand where the few remaining individuals occupy a number of rocky islets near the main land. The tuatara now receives government protection and it is unlawful to take a specimen without special permission from the Minister of Internal Affairs.

"A large cage is given over to the parrots and their allies among which are several species of cockatoos; one individual has the habit of greeting approaching visitors with its guttural 'Hello.' In the cage also are examples of the remarkable New Zealand kea or mountain parrot which, under natural conditions, has departed from an insect and fruit diet and has acquired the depraved habit of feeding upon the kidney fat of living sheep. . .

"Another large enclosure is given over to the kiwi or apteryx. . . . Examples of the morepork, the native owl, and of the pukeko which is allied to the extinct *Notornis* are also to be found in the park as well as other singular and unusual birds, some of which have become much reduced in numbers.

"Altogether, an exceedingly interesting assemblage of animals is contained in this reserve and Wellington is to be congratulated in its effort to uphold and foster an interest in the animal life of the Dominion. Such effort along lines of conservation and education is to be commended most heartily and many cities in our own country could profit by this example in the distant south seas."[1]

BIRDS

The following items which characterize the New Zealand avifauna are worthy of consideration.

1. Both in point of number of species and comparative abun-

[1] Stoner, Dayton, A Zoological Park in New Zealand, Proceedings Iowa Academy of Science, XXX, 143-145, 1924.

dance of individuals, New Zealand is far ahead of Fiji so far as birds are concerned. About two hundred and thirty forms have been recorded from the Dominion and surrounding seas. A relatively large proportion of these is maritime.

In all the seas adjacent to New Zealand, petrels, gulls, penguins and their allies form a conspicuous part of the avifauna making up approximately one-third the total number of species represented.

2. The affinities of New Zealand birds seem to lie with the Antarctic and South American forms. Perhaps former land connections permitted ready access of birds between what are now widely separated land areas. It is a well-known fact that a large number of the maritime birds of the Dominion are closely related to present-day Antarctic species. May it not be true, also, that Malaya has contributed something toward the development of this peculiar bird fauna as exhibited by the moas and their descendants?

3. A large proportion of the genera in both Carinatæ and Ratitæ are peculiar to New Zealand. Of the approximately seventy genera recognized, thirty are endemic.

4. The small number of raptorial birds—only a half-dozen species—is here again brought to one's attention. During my stay in the colony I observed only four or five hawks and but a single example of the curious morepork owl (*Spiloglaux novæ-zealandiæ*).

5. Woodpeckers (Pici) are lacking and the visitor is rather amazed to find that native sparrows (Fringillidæ) are also entirely absent. The several representatives of this family which do occur here have all been introduced.

6. Few species of migratory birds occur in New Zealand. Extended migrations are the exception rather than the rule among the birds of the Dominion, and most species may be classed as permanent residents. One of the most notable of these migrants is the godwit (*Limosa nova-zealandiæ*) which frequents the coasts of North Island. During June and July it breeds in Eastern Siberia, then crossing wide expanses of land and sea, arrives in New Zealand in November and December, not to leave until the following April. The regularity and periodicity of this migratory movement is remarkable.

7. The present existence of the flightless kiwi or apteryx (*Apteryx* sp.) which has been designated as "the most un-bird-like of feathered creatures," is worthy of special mention. At one time twenty-three species of flightless birds existed in New

Zealand but all have now become extinct except the apteryx, of which only four or five forms are generally recognized.

8. The former existence of gigantic and flightless moas, of which perhaps nine or ten species occurred, is one of the outstanding features of New Zealand ornithology. "About three or four hundred years ago a group of large flightless birds, some as much as ten to eleven feet high, roamed over the volcanic hills of this land. The aborigines of the country pursued these great moas, as they were called, destroying them for food and perhaps also making use of some other parts of the body. So persistently were these giant birds persecuted that to-day not one exists and we know of them only through legends and the remains that have been found. However, their miniatures, in certain respects, are represented in the present fauna of the islands by the vanishing kiwi."[2]

A unique and interesting feature in connection with the flightless birds of the Dominion is illustrated by the fact that while the subclass Ratitæ contains some forty species of modern birds included in five orders, two of these orders, Apteryges and Dinornithes, contain more than one-half of the species belonging to the subclass and are absolutely confined to New Zealand.

9. There is present a considerable number of introduced forms, principally from Europe and Australia, and most of them seem to be very successful in maintaining themselves.

Since a goodly number of birds can not be observed without more time and better facilities than I had at my disposal, I shall refer only to the commoner and most conspicuous forms on the island and adjacent seas and shall confine myself to a detailed account of but one or two collecting trips.

As the steamer approaches Auckland great numbers of red-billed gulls (*Larus scopulinus*) and black-backed gulls (*Larus dominicanus*) follow the vessel looking for any waste food that may be thrown overboard. The water about the wharf and the roofs of the wharf-buildings themselves are often thickly dotted with these birds, particularly the former species. Occasionally it goes inland for some distance, visiting parks and other places where food may be had. Such inland visits are said to immediately precede a rainy period.

Immediately upon landing in Auckland I was surprised and interested to find an old friend, or enemy, the ubiquituous, saucy,

[2] Stoner, Dayton, The Scientific Monthly, XVII, No. 2, 182, 1923.

belligerent and adaptive European house sparrow, *Passer domesticus.* It is present in some numbers and looks for all the world like Iowa examples of the species. While its presence is not confined to the cities it is, I believe, more common there than in the country districts.

Another introduced form which I came upon frequently in and about Auckland, in the bush at Rotorua and again in the vicinity of Wellington, was the Australian yellow-hammer. This yellowish, sparrow-like bird is fairly common.

Among other introduced forms should be mentioned the European starling (*Sturnus vulgaris*) the mynah (*Acridotheres tristis*) and the European skylark (*Alauda arvensis*). The latter was found commonly in open, grassy fields about Helensville and Onehunga, a suburb of Auckland. Its oft-described, characteristic method of rising from the ground and flying in a circle uttering the while a delicate continuous trill or warble is a never-failing source of delight. The only other bird with which it might be confused is the native pipit (*Anthus novæ-zealandiæ*) which occurs in the same situations and, with its streaked brownish plumage and white outer tail feathers, reminds me of our vesper sparrow.

Regarding the further importation of birds into New Zealand, Mr. J. G. Myers, a very active member of the Biology Division of the Dominion Department of Agriculture, and a gentleman whom it is a pleasure to know personally, makes the following comment: "Of the 130 species of foreign birds brought to New Zealand by private or official effort, only twenty-six have become thoroughly established in any considerable area. Of these, some, among which are numbered most of the more destructive species, are so nearly ubiquitous that their ultimate survival seems assured; while others are present in such small numbers, or inhabit such restricted areas that, were it not for fresh importations, they would probably die out altogether."[3]

Some time after arriving in New Zealand I went on a three days' collecting trip among the coastal bays and islands near Cowe's Bay, twenty-five miles north of Auckland. As is the case in such situations everywhere within a radius of fifty miles of Auckland, the black-fronted tern (*Sterna albistriata*) is common and breeds. Here, too, I encountered another well known and

[3] New Zealand Journal of Science and Technology, VI, No. 1, 40, 1923.

widely distributed member of the Larinæ, the New Zealand Caspian tern (*Sterna caspia oliveri*) which differs but slightly from our own *caspia*.

In the rocky bays and coves both the black shag (*Carbo c. steadi*) and the more abundant pied shag (*Hypoleucus v. varius*) breed. The mating season of the latter had just begun (July 23). These birds nest in colonies, usually on the branches of pahutokawa trees overhanging the water, and in such places scores of them could be seen engaging in various types of mating antics. This trip also included a visit to Gannet Island, a small bit of coastal volcanic rock of perhaps 12,500 square yards area where several pairs of New Zealand gannets (*Sula serrator*) had built or were building their crude nests on the bare and precipitous slopes.

Only a half dozen forms of Anseres are recorded for the Dominion, of which the brown duck (*Elasmonetta chlorotis*) is the most common. I saw scores of individuals on Lake Rotorua, a considerable body of fresh water 170 miles southeast of Auckland. The grey duck (*Anas superciliosa*) and the New Zealand shoveller (*Spatula rhynchotis*) occur not infrequently, the latter often in a semi-domesticated condition.

Of the existing Paludicolæ the most notable is the beautiful blue pukeko (*Porphyrio melanonotus*). In general appearance it is something like our purple gallinule but larger; it is not uncommon in marshy places. Certain recent observations seem to confirm the belief that the endemic notornis (*Notornis hochstetteri*), which has been thought to be extinct, may still exist in at least one remote part of the Dominion.

Although comparatively few migratory birds occur in New Zealand it is among the members of the order Limicolæ that the largest number of migratory forms is found. It is interesting to note that North America is included in the range of the following: knot. (*Tringa canutus*), turnstone (*Arenaria interpres*), golden plover (*Charadrius dominicus*) and the red phalarope (*Phalaropus fulicarius*). I did not see any of these, the only representative of the order which I was privileged to view being the oyster-catcher (*Hæmatopus unicolor*) along the shores near Onehunga.

Of Columbiformes, the only representative which occurs in the Dominion is the New Zealand pigeon (*Hemiphaga novæ-zealandiæ*) now confined to the more isolated and inaccessible bush. It is very shy and keeps well to the tops of the tall trees.

I saw only four or five examples of raptorial birds during my five weeks' stay in North Island. In the dense and little frequented bush about Roto Ehu one example of the curious morepork owl (*Spiloglaux novæ-zealandiæ*) was surprised by our collecting party. This bird is about twelve inches in length, strictly nocturnal and during the day usually retires to the thick bush. At night it comes out to feed on mice, rats, insects and other small nocturnal animals.

Several interesting representatives of the Psittaci occur in the Dominion although they, too, have been forced to the back country and remnants of native bush. Perhaps the best known form is the kea (*Nestor notabilis*) which has acquired a taste for the kidney fat of sheep. It boldly attacks lambs and even adult sheep with its sharp, curved beak and strong claws, often injuring or even killing these animals. On this account a continuous warfare has been waged against it until the species is now found only in the more inaccessible mountainous districts of South Island. The Government has aided in the destruction of the kea by offering a bounty of two shillings for each bird killed. Captive individuals may be seen in some of the zoological parks. I was permitted to photograph those in the park at Wellington. The peculiar kakapo (*Stringops habroptilus*), sole representative of the family, has been much reduced in numbers and is now seldom seen.

The commonest member of the Coccyges is the New Zealand kingfisher (*Halcyon vagans*) which is much like the Fijian form. Two cuckoos, both of which are migratory, occur in New Zealand. The shining cuckoo (*Lamprococcyx lucidus*) winters in northern Australia and New Guinea and arrives in New Zealand for the summer about October; the long-tailed cuckoo (*Urodynamis taitensis*) winters in islands to the north.

Only about forty species of passerine birds occur in the Dominion of which less than a dozen can be considered common. Some are peculiar to the region.

I suppose that the active and beautiful little white-eye (*Zosterops lateralis*) is the most abundant native land bird in New Zealand. Since first appearing in the country near Wellington in 1856 it has spread over both islands and has proved so valuable as an insect destroyer that it has become a great favorite. It frequents gardens, orchards and other cultivated areas, generally in flocks of some size. In the deep woods of the Mamaku bush, near Rotorua and Wellington, as well as in the Domain at Auckland, and even in Albert Park in the center of the latter city, this active and energetic bird with its olive-green head and tail, gray back and pale under parts and the ring of white feathers around the eye is of never-failing interest to the ornithologist.

The smallest and one of the most peculiar birds of the island is the rifleman (*Acanthidositta chloris*), a shy and active arboreal bird only three inches long, possessing some of the habits and appearance, except for color, of our winter wren. It is found only in the denser beech forests where it runs up the trunks of trees in a spiral manner something like a creeper. I saw this bird only in Gollins Valley near Wellington.

The family Meliphagidæ is represented by five species, two of which, the tui or parson bird (*Prosthemadera novæ-zealandiæ*) and the bell bird (*Anthornis melanura*) are the sweetest songsters in the New Zealand forests. The parson bird, so called because of the shining black plumage, and in the male, the presence of two fluffy feathers depending from the throat, possesses a clear, flute-like note and has considerable, imitative ability. It is fairly plentiful in the less frequented and wooded portions of the Dominion. During the course of an afternoon I came upon several small flocks high up in the trees near Lake Roto Ehu. The bell bird has a great variety of sweet, musical notes, one series of which is responsible for the common name. This bird, too, is a lover of the more remote forested areas.

One of the rarest birds in New Zealand is a muscicapid known as the North Island robin (*Miro longipes*), a blackish bird about 5½ inches in length and in general appearance quite unlike our own robin. It was my good fortune to see three individuals of this species in the Mamaku bush and Mr. Hamilton, a colonial, who had done a great deal of collecting in the Dominion, also had at this time, his first view of the species in the flesh. They are quiet birds keeping close to the ground where they feed upon grubs and insects.

The family Muscicapidæ boasts of three commoner representatives, the tomtit (*Myiomoira toitoi*), the grey warbler (*Maorigerygone igata*), and the pied fantail (*Rhipidura flabellifera*). All of these are more or less familiar in cultivated areas where, on account of their almost exclusively insectivorous diet, they are highly beneficial.

The fantail with something of the habits of the swallows, which latter are altogether absent in the Dominion, takes their place largely as destroyers of insect pests. Among low, shrubby bushes along the outskirts of the forests and in cleared areas therein, this tame and familiar bird flits about with broadly expanded tail in search of flying insects. Although often found in pairs, numbers of the birds usually frequent wooded areas and I have often called several of them close to me by rapidly kissing the back of my hand to which sound they respond as readily as does our chickadee or tufted titmouse.

"Long may the Pied Fantail thrive and prosper, in the face of cats, owls, naturalists, and the whole race of depredators; for without it our woods would lack one of their prettiest attractions, and our fauna its gentlest representative."[4]

The tit, a small black and white bird (about five inches), with a much shorter tail, frequents wooded areas also. However, it feeds in a different manner from the fantail in that it flits quickly from perch to perch, resting for an instant, then darts quickly to the ground or trunk of a tree where it feeds principally on small insects and their larvae.

The plain-plumaged grey warbler (four and one-half inches) frequents gardens, parks and forests indiscriminately, though it has become markedly adapted to conditions of settled areas.

It is of interest to conservationists to know that all the native land birds and most of the above-mentioned water birds except the shags have been placed on the protected list by the Dominion Government. And very rigid protection these birds receive, for even permission to take specimens for scientific purposes is seldom granted either to visiting or local scientists. Hunting areas are much restricted, all firearms must be registered with the police and other precautions are taken in an effort to give the birds a chance for their lives.

In an attempt to protect and preserve the rarer native birds the Government has set aside certain off-shore islands and mainland reserves as sanctuaries where birds may breed more or less undisturbed. Little Barrier Island in Hauraki Gulf (North Island), Resolution Island southwest of South Island, the National Park in Otago (South Island) are examples of this type. One of the reasons for the effectiveness of these sanctuaries is their inaccessibility. In a conversation with one of the scientists of the Dominion he said that he had attempted a landing at Little Barrier on three different occasions within a year and was unsuccessful

[4] Buller, W. L. A History of the Birds of New Zealand, 145, 1873.

each time. On a smaller scale may be mentioned the Domain at Auckland, a partly native preserve of two hundred seventeen acres and Wilton's Bush at Wellington, a beautiful preserve of some sixty acres where almost natural conditions have been allowed to prevail.

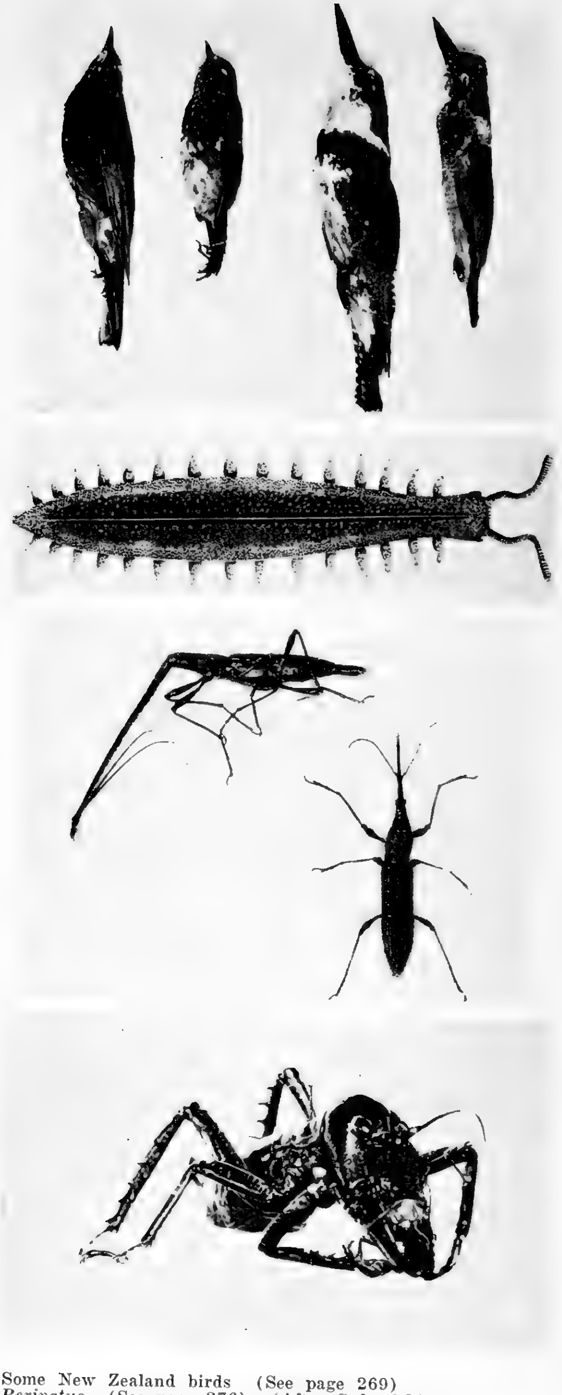
A number of the endemic birds of New Zealand have become extinct within comparatively recent times, witness the moas (*Dinornis* sp.). Others including the huia (*Neomorpha acutirostris*), the blue-wattled crow (*Callæas wilsoni*), saddle-back (*Creadion carunculatus*) and apteryx (*Apteryx mantelli*) have been much reduced in numbers. Of these I was privileged to view only the latter, in captivity at the Wellington Zoölogical Park.

"Only a few of these birds are left in the hills and more or less inaccessible bush of North Island, South Island, and Stewart Island. Of late an endeavor has been made to protect the species all over the Dominion and efforts toward conservation are being effected. Some of the zoological parks are so fortunate as to possess a specimen or two, the individual described in this article being, at the present moment, a captive in the well-kept park at Wellington. It is an example of the North Island kiwi, *Apteryx mantelli.*

"One morning, in company with the keeper and Mr. Harold Hamilton of the Dominion Museum staff, I visited the portion of the park reserved for this curious bird. Along one side of the low shaded enclosure flowed a small creek; near the middle of the area was a heap of sticks and brush, but nowhere was the kiwi to be seen. Entering the wire-netted compound and kicking at the pile of sticks the rather bedraggled and forlorn appearing occupant was soon dislodged and with reluctant and awkward gait it made off toward a shady corner, where it remained for a time quite motionless and apparently dazed by the bright rays of the sun.

"One is at once struck by the strange appearance of this tailless and all but wingless creature. It is about the size of a domestic fowl; it has a rounded and compact body; the neck is short, but the bill is long and slender; the legs are short and powerful. Add to this the much reduced wing, totally useless as an organ of flight, and the body covering of long, "stringy," hair-like feathers of a brownish or grayish-brown cast and the appearance of this singular bird is rendered still more un-bird-like. Indeed, the North Island kiwi can scarcely be considered beautiful.

PLATE XLVII



Some New Zealand birds (See page 269)
Peripatus (See page 276) (After Sedgwick)
New Zealand weevils, male and female (See page 280)
Weta, a strange New Zealand insect (See page 278)

Gymnosperm forest near Ohakune, New Zealand (See page 291)
Gymnosperm forest, after lumbering (See page 291) (Photos by Wylie)

"The kiwi may truthfully be said to have the longest 'nose' of any known bird, for the slit-like, ventrally placed nostrils are located near the *tip* of the six-inch, semi-cylindrical bill, a condition which prevails in no other bird. Numerous stiff, bristle-like feathers cover the face and base of the bill.

"The lower leg is covered with irregular, horny scales, and the three long, strong front toes are furnished with heavy, sharply-pointed claws. A small first or hind toe is also present.

"When handled, our zoological park kiwi showed resentment by hissing and kicking—not backward as much as forward—and with sufficient force to cut one's flesh deeply. It offered no resistance with the formidable-looking bill.

"Kiwis are hardy, nocturnal birds which hide in holes or dark places during the day and come out at night to feed mainly upon earthworms and also, to some extent, upon vegetable material.

"Under natural conditions a hole in a bank or under the roots of a tree is chosen as a nesting site and, in a burrow, partly natural, partly excavated by the female, the one or perhaps two white eggs are laid. In proportion to its size the kiwi lays the largest egg of any living bird, a female twenty-five inches in length producing an egg five inches long and three inches broad. The birds will breed in captivity, the individual under discussion having laid eggs which, unfortunately, were destroyed before hatching by the flood waters of the adjacent stream.

"Contrary to the general rule among birds, the male incubates the eggs and after a period of about six weeks the helpless young are hatched. They acquire strength rapidly and in a few days are able to join the parents in searching for food.

"A very well-executed habitat group, showing one egg, three young and four adults of the North Island kiwi, is exhibited in the Auckland Institute and Museum.

"It is to be hoped that such satisfactory protective measures for the kiwi may be taken by the New Zealand government that it will be in no danger of the fate that has befallen its even more remarkable precursors, the moas."[5]

Except for man's interference, in the way of reckless slaughter which has now been curtailed, and the cutting down of a great deal of the native bush which has resulted in a diminution of the

[5] Stoner, Dayton. A Flightless New Zealand Bird, The Scientific Monthly, XVII, No. 2, 182-184, 1923.

number of safe retreats, I know of no good reason why most birds should not flourish in New Zealand. Mongooses, snakes, and native carnivorous mammals are all absent. Pigs, weasels, rats, and stoats have been introduced and while they cause some loss among the bird population, various agencies contribute toward holding them in check.

Due to protective measures, it is possible that at least some of the birds will "come back." New Zealand has learned her lesson. Conservation is now the watchword, and laudable efforts are being made to inform and educate the people along these lines. The Dominion is still entitled to be called, "The most interesting ornithological province in the world."

TERRESTRIAL ARTHROPODS

In conformity with the plan which has been followed in discussing the terrestrial arthropods of Fiji, it may be appropriate here to enumerate some of the general characteristics of the New Zealand forms, along with certain items pertaining to their habits and occurrence as well as our experiences in taking a number of the more striking and interesting members. Since North Island is much larger than Vitilevu and possesses an abundant and varied fauna, a correspondingly greater part of it must be omitted from this discussion owing to the physical impossibility of becoming acquainted with much of it in the four working weeks I enjoyed in the Dominion.

From an entomological standpoint, our visit to New Zealand was ill-timed, for July and August are the mid-winter months there and many of the insects are in hibernation at that season. It was only on the warm, sunny days when they were flying that we enjoyed any success in sweeping the vegetation; even then our catches were confined to the smaller and less conspicuous forms. Most of our specimens were taken by turning over stones, logs and leaves and by digging into the earth and decaying down timber.

With respect to the affinities of New Zealand insects, it seems likely that the North Island fauna has been derived largely from that of the South Island, for often only subspecific differences obtain in forms found on the two islands. Possibly the South Island fauna has been derived, in turn, either wholly or in part, from South America and Australia; at any rate, as a general proposition, it seems to be of a more primitive type than the North Island fauna.

Proportionately, a considerable number of exotic forms of terrestrial arthropods are found in New Zealand, more than two hundred species of European and Australian origin having been introduced into the Dominion at one time and another. A fair number of cosmopolitan species is also present. Since several of the New Zealand cities are ports of call for ships from all parts of the world, it is probable that the vessels and their contents are disseminators of many kinds of insect life in spite of the precautions taken to prevent it.

"If we review the noxious insect fauna of New Zealand it will be found that of the approximate total of species already recorded, the indigenous element equals only eighteen per cent. The countries of origin of the exotic eighty-two per cent. are Europe, Australia, North America, Pacific islands and South Africa. The European element is by far the most prominent, making up about sixty-eight per cent.; of the others, the Australian accounts for approximately nine per cent., the North American two per cent., and the Pacific islands, South African, and cosmopolitan one per cent. each. The most pronounced elements, therefore, of our destructive insect fauna are the European and the indigenous, but in proportion the latter is hardly one-fifth of the former, although there is every likelihood of additional native forms becoming injurious."[6]

Although some large forms occur in the Dominion, the number of conspicuously colored representatives is few. A miscellaneous collection of New Zealand insects, such as I saw in the Dominion Museum at Wellington, has a peculiar, "old-fashioned" appearance about it. There is a scarcely definable something that savors of the long ago; the curious shades and combinations of colors give the observer the notion that their wearers have long since passed on.

Back of the high hills which surround Wellington, and one and one-half miles northwest of the city, about sixty acres of native forest, known as Wilton's Bush, have been set aside as a government preserve. Hills and deep valleys, woods of remu, tawa and matai, partly cleared and burned-over areas with huge decaying limbs and trunks of trees, here and there a stalk of prickly, yellow-flowered gorse adding a touch of color to the scene, and below, a beautiful clear stream winding its way among this riot of

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[6] Miller, David. The Status of Entomology in the Economy of the Dominion, N.Z. Journ. Science and Tech., II. Nos. 4 and 5, 270, (July) 1919.

plant growth—such is the setting in which the naturalist here finds himself.

Before we left the University I had hoped to be able to secure for our collections some examples of that peculiar and aberrant, slug-like arthropod called *Peripatus.* The time of our departure from New Zealand was but a few days away and still I had not captured any of the animals, although I had been informed that they were to be found in Wilton's Bush. Here, then, was my last chance. So, armed with a heavy collecting knife, I began to attack the multitude of stumps and logs in an effort to discover the object of my search, *Peripatus novæ-zealandiæ.*

After some minutes, down within the damp, well-rotted interior of an old remu log, I uncovered a cylindrical, caterpillar-like, velvety-black creature an inch and a half in length—the long-sought *Peripatus.*

Peripatus has been known to zoologists for about one hundred years. Something like fifty species are known, principally from South America, Africa and the Australasian region. It has engaged the attention of scientists because it has seemed to be a sort of "missing link" between certain worms, on the one hand, and the air-breathing arthropods on the other. However, it may be nearer the truth to regard *Peripatus* as an offshoot—one of the lower branches—from the base of the arthropodan family tree.

The skin of the New Zealand species is deeply pigmented above, and thickly spotted with reddish brown. It is not jointed but is thrown into a multitude of fine transverse wrinkles. Although abundantly supplied with legs, fifteen pairs in all, each of which is furnished with two claws, my find moved very slowly and deliberately with a kind of undulatory motion similar to that of a caterpillar. Neither the dark surroundings nor the nocturnal habits of *Peripatus* demand keen eyesight, and accordingly, it possesses but a single pair of simple eyes which are able to distinguish only between light and darkness.

Its acquaintance with the outer world is gained largely through impressions received by a pair of extremely sensitive antennae which are in constant motion. On the under side of the head the elongate-oval mouth is surrounded by a swollen lip which is raised into a series of conical papillæ. Within the mouth is a pair of horny jaws which assist in masticating the various kinds of animal matter which serve as food.

Possibly the most striking external feature is exhibited when the animal is disturbed. On such occasions *Peripatus* raises the anterior part of the body and, from a blunt, hollow, wart-like projection on either side of the head, ejects with considerable force, a harmless but very sticky substance which is the product of the slime glands within the body. This secretion is also of use to the animal in entangling its prey.

"After leaving the oral papillæ the clear fluid hardens into a series of viscous stands bearing, at fairly regular intervals, minute droplets. Although harmless, it is very sticky, coming away easily from the animal itself but adhering tenaciously to other objects including one's fingers. I can not agree with Hutton's statement (Ann. Mag. Nat. Hist., XVIII, 362, 1876) that "This viscid fluid is for offensive and not defensive purposes," for in my experience it was certainly used in a defensive capacity. And I do not doubt that a spray of this fluid would, to say the least, prove very disconcerting to any enemy such as spiders or predaceous beetles, both of which live in the same situations as *Peripatus.* In 95% alcohol the slime collects in the form of a flocculent mass."[7]

Of the several interesting internal structures which particularly relate *Peripatus* to the insects, the most important is the system of tubules or tracheæ which open to the exterior through minute pores scattered irregularly over the skin. These tubules carry air directly to the different parts of the animal's interior.

Possibly in his search the collector will now and then come across a little grayish fellow one-fourth to one-half inch long, an exact miniature of the adult animal. This young one, along with perhaps fifteen or twenty brothers and sisters, had been brought forth alive a few weeks previously by a sleek and well-fed female.

With the assistance of Mr. Hamilton and Miss Castle of the Dominion Museum and of Mrs. Stoner I was able to secure, in two one-half day trips to Wilton's Bush, over one hundred specimens of *Peripatus;* and since it is not the good fortune of many people to see the animal, which is a never-failing source of interest to the layman as well as to the naturalist, this lot is of more than passing concern.

In the Orthoptera more than seventy-five species are recorded from the Dominion. One finds the usual number of grasshoppers, locustids, crickets and stick-insects included in the list.

The large, black, brachyelytrous cockroach (*Blatta forticeps*)

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[7] Stoner, Dayton, collecting Peripatus in New Zealand, Science, LVIII, No. 1505, 342, 1923.

with its offensive, odoriferous qualities, and known locally as the "Maori bug," is common in the wooded regions under the bark of dead and decaying trees. Another member of the family (*Blatta conjuncta*), a pale form with long wings, is an inhabitant of the beech forests in Gollins Valley and elsewhere.

One of the most striking though not abundant groups of orthopterans occurring in New Zealand is the family Stenopelmatidæ. Certain of its members look something like overgrown grasshoppers devoid of wings. These insects are commonly known by their Maori name of "weta." While they are distributed throughout most of the warmer parts of the globe, they appear to be most numerous in New Zealand where they usually frequent the forests, climbing trees or hiding under loose bark; sometimes they inhabit fallen and decaying wood; a few species are subterranean and some live under stones. They are nocturnal insects and most are solitary in their habits; their food consists of vegetable material. All are good climbers, but the larger species, in spite of their elongate and muscular hind legs, the tibiæ of which are furnished with long, sharp spines, are poor jumpers; the smaller forms can hop and run swiftly. Tegmina and wings are lacking in the New Zealand representatives. In coloration they are usually some shade of brown.

At Wilton's Bush we frequently came across one form, (*Hemideina megacephala*) in the moist, decaying remu logs where we were hunting for *Peripatus*. The head of the adult male is very large, the face is long and flattened and the elongate jaws give the possessor an exceedingly formidable appearance. A few measurements of a male and a female in my collection will give some idea of the peculiar and unusual proportions of this insect:

	Male	*Female*
Length of body	51 mm.	51 mm. (exclusive of ovipositor)
Length of head	33 "	15 "
Length of mandible	18 "	7 "
Width of head at the widest part	17 "	9 "
Length of hind leg	65 "	71 "

The males of *Deinacrida rugosa,* another less common though larger and more robust form, lack the facial expanse of this species.

Other and smaller forms were taken in the beech forest at Gollins Valley and under moss at the roots of trees in Kauri Gully near Auckland.

In the order Dermaptera the family Forficulidæ is represented by a few forms among which is the common earwig, *Anisolabis littorea;* especially fine and large examples were taken from decayed logs at Helensville. At Gannet Island, in Cowe's Bay, all stages were abundant in debris under the nests of the New Zealand gannet (*Sula serrator*). No doubt the insects perform a valuable service so far as the birds are concerned, in the removal of waste and decaying materials.

Of the Neuroptera (nerve-winged insects), about eighty species are described from the Dominion. One of the entomological problems still awaiting investigation there, is the value of the aquatic insect fauna as fish food; and among these aquatic forms the larvae of Neuroptera as well as of Trichoptera (caddis-flies) and Ephemerida (may-flies) make up a considerable proportion.

The proportionately small number of true bugs (Hemiptera) described from the Colony is striking; exclusive of the aphids, scales and psyllids, slightly over one hundred species have been recorded. Only nine species of stink-bugs (Pentatomoidea) are included in this list. One of the largest and gaudiest of these is the greenish Australian form (*Glaucias amyoti*) an example of which I took in Kauri Gully. It is closely allied to the cosmopolitan southern green plant bug (*Nezara viridula*) which also occurs in the Colony.

One of the commonest New Zealand plant bugs (*Rhopalimorpha obscura*) is included in this group. It is an elongate linear species something like our *Mecidea longula* and can be recognized by the pale, mid-dorsal line. I found examples of this form hibernating in the grass at Wilton's Bush.

Of the Homoptera, the family Cicadidæ is one of the largest, containing thirteen forms, all of which are included in a single genus. The Cicadellidæ (leaf-hoppers) and the Fulgoridæ (plant-hoppers) are represented by fifteen species each. There are no endemic plant-lice (Aphididæ) but about twenty forms have been introduced.

Apparently much remains to be done in making known the hemipterous fauna of the islands and at the present time the frequent papers of Mr. J. G. Myers, of the Department of Agriculture, are of much value in this connection.

The beetles (Coleoptera) make up by far the largest proportion of insects so far as number of species is concerned; the families Carabidæ and Elateridæ are particularly well represented while a surprisingly large number of weevils (Rhynchophora) is recorded.

Of the latter, only two will be mentioned; one, a small, brownish form, four mm. long, (*Stephanorhynchus attelaboides*), covered with scales and with a slender, elongate prothorax has a prominent ridge on each regularly punctate elytron. The long slender femora are markedly club-shaped, the posterior ones being furnished distally with a low, sharp tubercle in addition. The other form (*Lasiorhynchus barbicornis*) exhibits an unusual sexual dimorphism so far as size is concerned; a male in my collection has a total length of 81 mm. of which the beak alone makes up 41 mm., while in the female, with a total length of 50 mm., the beak makes up but 17 mm.

Several species of tiger-beetles are found in the Dominion, the commonest and most elusive one being *Cicindela tuberculata.*

At Helensville we found a large brownish click-beetle (*Lacon variabilis,* family Elateridæ) in some numbers. Often three or four individuals were grouped together in a decaying log; sometimes only a male and a female were together, the latter almost invariably resting on the back of the male.

In the beech forest in Gollins Valley we secured several fine stag-beetles (*Lissotes reticulatus*) some of which bore small mites; these beetles seem to associate together in much the same manner as do the elaterids.

Along the shores of Rokino Island, under an old gasoline tin partly filled with crushed rock, I found a great mass—perhaps a good-sized handful—of a large, brownish darkling beetle (family Tenebrionidæ) in hibernation. This peculiar method of association during the winter months seems to be shared by these forms also. Another tenebrionid (probably *Uloma* sp.) was common at Wellington.

In the moist, moss-covered earth at Mamaku bush a beautiful scarabæid (*Odontria* sp.), thickly covered with fine yellowish pile was taken. The several species of this genus, the larvæ of which are commonly called ''grass-grubs,'' are of considerable economic importance; for, as the native bush is cut down and cultivated land takes its place, the grubs advance upon the more succulent vegetation where they cause considerable damage to the roots.

One is at once struck by the paucity of butterflies (Rhopalocera) in New Zealand, not more than about twenty-five species having been recorded from the Dominion; among these the most conspicuous is *Vanessa gonerilla* which is closely allied to our red admiral (*V. atalanta*); the thistle butterfly (*V. cardui*), of almost world-wide distribution, also occurs in the Colony as does the monarch (*Anosia plexippus*).

On the other hand, moths (Heterocera) are unusually abundant, something like seven hundred species being included in the faunal lists. A cosmopolitan representative of the group is the army worm, *Leucania unipunctata*.

New Zealand possesses a dipterous fauna of considerable magnitude; it is remarkable for the proportionately large number of crane-flies (Tipuloidea) represented, for about three hundred fifty species have been recorded. An abundance of wet banks along small streams, as well as a large amount of moist, decaying vegetation, offers favorable breeding-places for these insects.

At Rotorua I found the fork-tailed larvæ of *Ephydra* in the hot pools as well as adults on the surface and near the margins of the hot water. A slimy, dark green vegetable growth covers the margins and the bottoms of most of the streams and serves as food for several other species.

Two of the most frequent visitors at this place were flies (Diptera). A small blackish form was very abundant. Another large, black species fed greedily on the algal growths. Sometimes the flies rested on the water while feeding but if immersed in it they quickly succumbed. A species of crane fly was also discovered about these pools.

Two species of Hemiptera were also taken here One was a small water strider which glided rapidly over the surface of the hot water and apparently suffered no inconvenience from it. In addition a species of small hydrophilid beetle (Coleoptera) and its larvæ were found in the water.

Among the familiar forms, the drone-fly (*Eristalis tenax*), the blue-bottle fly (*Calliphora erythrocephala*), the house-fly (*Musca domestica*) and the stable fly (*Stomoxys calcitrans*) are pretty generally distributed.

Something like two hundred species of Hymenoptera (ants, bees, wasps, etc.) have been recorded from the Dominion but only a small proportion of these are ants. Some writers believe that the ant fauna of New Zealand is a remnant of an Australian fauna, and that it became disseminated by submersion and climatic changes incident to the ice age. The most typical New Zealand ants are found on North Island; it is said that very few species occur on South Island.

Spiders (Arachnida) and their near allies are common, upwards of three hundred species having been recorded. About Auckland a few were swept from vegetation but most were found in decaying stumps and under bark, sticks and logs. Everywhere on the open rolling lands which are of poor quality and on the sandy flats near Rotorua the shrubby manuka or tea-tree (*Leptospermum scoparium*) grows abundantly, and on this spiders seemed to be particularly common.

Few poisonous or venomous animals inhabit New Zealand. However, one of the small spiders, known locally as the katipo (*Latrodectus hasselti*), although no longer of frequent occurrence, falls under this group. The general black coloration and red abdominal band serve to distinguish it.

We found another and larger spider with yellowish-brown cephalothorax, (*Porrothele antipodiana*) in Wilton's Bush.

So far as individuals are concerned, myriopods are common. Although large centipedes, some as much as seven to nine inches in length, are sometimes found, most of the representatives of the group (Chilopoda) are much smaller. At Mt. Eden and One Tree Hill we found good myriopod collecting under pieces of lava lying in the bottom of the old volcanic craters. A long and exceedingly slender form was frequently discovered in decaying logs.

Millipedes (Chilognatha) occur widely in damp situations. In Kauri Gully a small form with protruding eyes was taken at the base of kauri trees and also in sweepings from vegetation. A black species with red spots along the sides was abundant in the Mamaku bush; on July 29, numbers of these millipedes were found in copula.

In conclusion, it seems to me that one of the most important acquisitions which comes to the participants of such a trip as ours, is the enlargement of one's horizon and one's outlook upon life for having had these new experiences in new places and under conditions which are out of the daily routine. And, too, the establishment of professional contact with workers and institutions is an important factor in such an enterprise. The least service that we now can render is to share these experiences with others through written and spoken word.

CHAPTER XVII

EXPERIENCES OF A BOTANIST IN NEW ZEALAND

By Robert B. Wylie

The sturdy Navua which carried me from Fiji to New Zealand was reported to have been the smallest British vessel in transport service during the Great War. She was a very easy-riding boat, however, and the four-day journey, following the strenuous weeks in Suva, was most enjoyable. Life on board was simple and very restful in contrast to the formality of the Niagara. The Navua was returning from her trip out to Samoa and carried many New Zealanders who were making a midwinter excursion to the tropics. A number of Scotch from the region of Dunedin were aboard and were about the friendliest people I have encountered; their sincere "good morning" salutations sounded most cheerful to one who had been much alone for weeks. Mr. and Mrs. Ashbel Welch, of Philadelphia, whom we had met on the trip down to Fiji and who had meanwhile journeyed out to Samoa, were already on board and had kindly made reservation for me at their table. They were experienced travelers and contributed much to the pleasure of this voyage.

It was an interesting experience to ride southward from Fiji, each day bringing cooler and cooler weather. The ship's officers and stewards soon changed from white to blue uniforms, and towards the end of the journey we encountered cold July winds sweeping down from the south. The morning of July 7 found the Navua resting at anchor in the beautiful land-locked harbor of Auckland. After inspection when we ran in to the pier I was pleased to find Professor Nutting on the wharf, and he soon conducted me to headquarters, the others having reached New Zealand ten days earlier.

The Iowa party was established near the Auckland Museum where ample working space had kindly been assigned to our group. The late Professor T. F. Cheeseman, Director of the Museum, and his associate, Mr. C. J. Griffin, showed us every courtesy, and their efforts were deeply appreciated. Professor Cheeseman, who was the outstanding systematic botanist of the Dominion, was then in rather delicate health but was able to be of great service to all of us, but especially to me. We were all grieved to learn of his death a few months ago. He gave helpful advice about reaching the more interesting regions near Auckland and determined for us the plants brought in from day to day. Since most of their larger plants were in vegetative condition at that season of the year identification was doubly difficult and a mere morphologist deeply appreciated the help Dr. Cheeseman was so well qualified and so willing to give.

The three principal islands constituting the Dominion of New Zealand extend in a north and south direction from 34° to 48° South latitude. This would correspond to that portion of our eastern coast from Wilmington to Newfoundland. Or, compared with the interior of our country, these islands would extend from near Little Rock, Arkansas, to Grand Forks, North Dakota, which is about 120 miles north of Duluth. North Island is 515 miles long, and has an area of 44,000 square miles. It is separated by Cook Strait from South Island which is somewhat larger. The southernmost is Stewart Island which was not visited by any of our party.

The proximity of all parts of these islands to the sea gives them an oceanic climate with diminished extremes of temperature and insures relatively high humidity. The rain fall of North Island averages about fifty inches with considerable variations in parts due to topography, especially about the higher mountains. The distribution of precipitation throughout the year is fairly uniform with an increase during their autumn and winter months. North of Auckland conditions are more nearly subtropical. The central part of North Island is considerably wider and interior portions show greater daily and seasonal range. There freezing temperatures frequently prevail at night. While it was midwinter during our visit there in July and August not even the cooler end of North Island had snow though the mountains were white on their sides.

One must not gather from these statements too optimistic an opinion of the delights of a New Zealand winter, however moderate the descriptions may sound. Accustomed to the rigors of our Iowa climate we anticipated weather like our early autumn but found something quite different from our Indian Summer. Though the weather in North Island was not severe there was a nagging chill in the air which proved quite disturbing to all of us. Perhaps our real difficulty was not the cold of outdoors so much as the cold indoors due to the inadequate heating facilities. The New Zealanders' aversion to fire in all forms is most marked! Their cold hotels, cold stores, cold trains, and cold dwellings rather "got on our nerves" and threatened our health. While the New Zealand friends professed to enjoy the English tradition with respect to low room temperature we noticed that they crowded about a good fire on those rare occasions when burning wood was seen.

However uncomfortable this winter climate for people, it is not so unfavorable for plants. Even though the major portion of these islands has a south temperate position corresponding to that of Iowa in north latitude, their vegetation is practically evergreen. Trees on North Island with very few exceptions retain their foliage throughout the year, though introduced forms, such as the oaks, follow their traditional habit. The forests, and fields as well, must present a remarkably uniform aspect throughout the year. Of South Island I can not speak from personal experience, but both latitude and altitude conspire to give it a much more rigorous climate as a whole. There are local exceptions where mountains shelter favored and fruitful areas such as that at Nelson at the north end of this island.

Due to these expressions of its ocean climate, mild winters and high humidity, the plants of North Island are mostly of the thick leaved evergreen type. Through modification of texture and stomata their leaves are able to function throughout the year without undue hazard to the plant. Compared with our deciduous foliage these leaves are much thicker and tougher, with multiplied epidermal layers, heavy mechanical tissues, greatly thickened cuticle, and numerous trichomes. In these respects they are comparable to the strand vegetation seen in Fiji. As will be noted later the strategy of New Zealand's agriculture grows out of a climate permitting evergreen vegetation. On cultivated land this means favorable pasturage throughout the entire year, with lessened need for hay and grain.

The flora of New Zealand presents an interesting group of plants about which much has been written. With a great diversity of habitat ranging from ocean-shore through coastal formations and uplands to mountains of considerable height, the narrow limits of the country afford contrasts and transition areas usually much farther dissociated. Perhaps for this reasan the country has been termed, by some travelers from larger continents, an area of ''samples'' but without extensive development of the various types because of the small size of the islands. This diversity insures a rich flora both as regards individuals and species. A considerable proportion of the higher plants is endemic. Dr. Cockayne estimates that 74% of the vascular plants is restricted to New Zealand. Or, if the more readily distributed ferns and monocotyledons are disregarded, the proportion of endemic species among the dicotyledons and gymnosperms rises to 85%. Superimposed upon a primitive New Zealand flora, probably that of an ancient Antarctic land mass, are its derivatives together with later migrants from the neighboring land areas,—Australian, Malayan, etc., as well as others with kinships reaching out much farther.

In comparison with our north temperate flora one finds little in common. For instance their great coniferous forests are mainly taxids including the splendid *Dacrydium, Podocarpus, Agathis, Araucaria,* etc., while our conifers include the pine, spruce, fir, and hemlock types.

The northern part of North Island is the home of the kauri pine, one of the noble but vanishing trees of the world. Running out from Auckland I saw considerable groves of them, but was unable at that season of the year to get north to the regions where lumbering operations are now being carried on. This tree, *Agathis australis,* is a southern hemisphere gymnosperm of unique appearance. The lower branches are shed as the tree grows, their detachment being achieved by a regular abscission-layer which smoothly cuts off the limbs at the base. The higher branches are spread out abruptly into a more or less rounded top which crowns the long, smooth and unbranched axis. This log is so smooth and symmetrical that it looks as though it had been turned out with a lathe. *Agathis* has quite large leaves which are two or three inches long and three-fourths of an inch wide. We saw another species of this genus in Fiji, *Agathis vitiensis.*

It is from the secretions of this tree that the noted kauri gum is secured. This resinous substance is formed within cavities of the trunk in considerable masses. The museum in Auckland has several fine specimens of many pounds weight looking like high grade resin and taking a beautiful polish. Naturally this stable substance does not decay with the decomposition of fallen logs but is left in the soil or on the ground of areas once covered by forests of this species. Some such regions are now open country or even under the sea margin. A considerable number of "gum-diggers" gain a livelihood by excavating resin from the regions of former forests. They explore the ground with long pointed rods by means of which they find even deeply buried masses of resin. New Zealand exports annually great quantities of this gum which is used as an ingredient of varnishes.

The forests of North Island are given a tropical aspect by the great numbers of perching and climbing plants as well as by the numerous fern-trees throughout this island. The perching-lilies (*Astelia*) are conspicuous on the branches of larger trees together with epiphytic ferns and lycopods. Climbing plants of the most varied forms abound, ranging from climbing ferns to the supplejack, *Rhipogonum scandens,* whose slender stems are almost unbreakable.

The ferns in general are varied and abundant. They spread out everywhere in a great variety of forms. The delicate filmy ferns, *Hymenophyllum* and *Trichomanes,* are common in the rain-forests. Most conspicuous are the beautiful tree-ferns which grow commonly to a height of twenty to thirty feet, and in favored places nearly twice that high. They belong to three genera, *Cyathea, Hemitelia,* and *Dicksonia,* and Cockayne reports six of their species as endemic. Related groups include the numerous lycopods and the rare *Tmesipteris* which grows sparingly on the trunks of tree ferns.

Certain introduced plants, here as in Fiji, seem to offer a problem. For example, considerable areas of northern New Zealand were possessed by the gorse and it would be difficult to imagine a more unfavorable visitor. Its thorny stems form such dense growth that grazing is nearly impossible. It may be recalled by some that it was this plant which, when first seen by the great Linnæus, caused him to fall on his knees in admiration of its beauty. An apochryphal story has it that when his knees struck the thorns of some of the stems lying on the ground he forthwith sprang up in a less devotional mood.

The Auckland district has a number of small extinct volcanic cones, some of them quite low and but a few hundred feet above the level of the ocean. One of the higher and most symmetrical of these is Rangitoto, a mountain-island approximately one thousand feet in height which stands in the edge of Hauraki gulf, which is the outer harbor of the city. It sides are still largely covered by rough lava only partially possessed by vegetation.

On the ferry boat when I was running over to this island I noted an alert old gentleman who with three or four companions was evidently to spend the day on the mountain. I had planned to return to Auckland on the noon ferry and wishing to get some advice about the place before these visitors scattered, I spoke to this old gentleman and asked about the large seaweeds on the rocks about the pier. He looked at me keenly for a moment, then said, "You are a stranger here, you are interested in plants, and you are going to spend the day with me on the mountain." I told him of my plan to return on the noon boat but he brushed aside my objections, assured me that he had plenty of lunch for two, sent his companions on ahead, and remained behind to pilot me up the mountain. A trail has been constructed making a good path to the summit over the rough lava rocks.

I was indeed privileged to have such a guide and companion for the day. Mr. Wilson is a business man who first climbed Rangitota fifty years ago. Deeply interested in both plants and animals he has been a weekly visitor to the island for half a century. He was one of those who fostered the plan, which happily succeeded, to have the mountain converted into a park with conservation of its plant and animal life.

We journeyed leisurely up the trail with many pauses and side excursions noting the interesting transitions from black, naked lava to forested areas nearer the top. A pioneer arborescent form is the beautiful "Christmas tree" of New Zealand, *Metrosideros tomentosa.* Trees of this species stand singly or in groups among the black blocks of scoria. At a higher elevation there are well developed forests of moderate sized trees. Botanists have reported 180 vascular plants for this lava island which is one of the most interesting of ecological areas, being now in transition from naked rock to mixed vegetation.

At noon Mr. Wilson left the main trail and led the way to a shack hidden among the trees not far from the summit. First unlocking the door he brought out camp equipment and after heating water, from the nearby spring, he scalded the dishes and cooking utensils. He then proceeded to make tea and served the lunch.

In the afternoon we climbed to the top, looked over into the grassy cup of the crater at the tip of the cone, and enjoyed for

Durvillaea antarctica, a large fucoid sea-weed, near Wellington (See page 295)
Durvillaea antarctica growing on rocks (See page 295) (Photos by Wylie)

PLATE L

Metrosideros tomentosa growing on lava, Rangitoto Mt. near Auckland
(See page 288)
Looking down the lava slope of Rangitoto Mt. and over harbor of Auckland
(See page 288) (Photos by Wylie)

an hour the splendid view from the summit. The blue waters of Hauraki Gulf with its seemingly motionless ships spread out before us, and in the distance to the right were the various suburbs of the city of Auckland. Below was the rugged face of the mountain, much of it barren and broken as if lava had recently poured out. But a vigorous plant life is slowly subduing its surface and changing the bleak bareness to living green. My host parted from me at one of the suburbs touched by the ferry. As we separated, knowing we should probably never meet again, I tried to thank him for his courtesies. He touched his hat and was gone, but not forgotten, for many men whom I have known all my life have never impressed me as did this fine gentleman with whom I tramped but a day.

Through the courtesy of Professor Thomas L. Lancaster, of Auckland University College, I was given the privilege of meeting Mr. E. LeRoy and opportunity to visit his private park in one of the suburbs of Auckland. This park is a tract of thirty or forty acres of abrupt hills and deep valleys, the whole clothed with luxuriant rain-forest vegetation. Mr. LeRoy is a business man who has studied the plants purely as an amateur but is nevertheless not only an enthusiastic but also a competent botanist. Indeed he is typical of those wonderful New Zealanders, many of whom seem to be so versatile. Aside from all fields of information relating to the vocations they constantly surprised one by the breadth of their knowledge and attainments and seemed almost equally at home in many fields. So while Mr. LeRoy offered apology for his lack of professional training in botany he need not have done so for he is a skilled naturalist, one who knows his native plants and thoroughly understands the vegetation of this region.

With Mr. LeRoy and Professor Lancaster I traveled for hours along the numerous paths which Mr. LeRoy has at considerable expense established through his tract, making it easy for one to reach all parts of his park. One noticed also that large tiling has been placed in certain gullies to carry the drainage and lessen erosion, and that the flood plain below had been easily modified into a series of shallow ponds within which were many aquatic plants. To all of this Mr. LeRoy invites the public with the request that the plants be left undisturbed. But he told me, in response to my questions, that he found it very difficult to control the park which is wholly without police or protection. Though many people violated the courtesies, cutting, carrying off and otherwise destroying the plants, he said he was hoping to continue the plan as he wished the people of Auckland to enjoy all that he had as long as possible. Within this preserve are many fine specimens of the species of major forest trees and a great wealth of small woody plants including shrubs, twiners and also certain perching plants. The forest floor had a wealth of mosses and liverworts and a luxuriant growth of ferns; the most noble of these were the huge tree ferns *Cyathea medullaris* in the borders of the stream valley, some of which were over fifty feet in height. Mr. LeRoy assured me that this was a measured and not an estimated height.

Late afternoon took us up past his home but he walked a mile with us down to the ferry-landing from which we took the boat back to Auckland. As we were walking to the ferry, I thoughtlessly expressed to Mr. LeRoy my hope that he had sons who could enjoy what he had built up and carry his public spirit into the next generation. He did not reply for a moment and then said, ''My only son entered the war and was lost.'' This illustrated to us again the tragedy of the Great War to New Zealand and all other parts of the British Empire, where apparently every able bodied man of anywhere near military age was in the service. You never asked a young man, ''Were you in the war?'' If you mentioned it at all you simply asked, ''What was your service?'' It ill-becomes us of this ''great and friendly nation,'' as they described our America, to talk much about the war. We can never explain to these friends our tardy entrance into the conflict nor our hasty withdrawal following its close.

Leaving Auckland on a very early train the next morning I was surprised and pleased to find Mr. LeRoy searching through the train to find me. He had taken the earliest ferry on that chilly winter morning in order that he might place in my hands a number of fine steroscopic views of his park. I have used these with all of my classes since my return and the students have greatly enjoyed the fine pictures of Mr. LeRoy's preserve and its great fern trees.

Late in July I moved from Auckland to Wellington at the southern end of North Island and traveled the entire distance of over four hundred miles by daylight. In this way I was able to study a trans-section of the island noting the general aspects of the natural vegetation and the agricultural development as well. On this trip short visits were made at Ohakune and Palmerston.

The two days at Ohakune gave a good opportunity to see the mixed taxid association as there were fine *Podocarpus* and *Dacrydium* trees in this region. North Island, New Zealand, was originally quite largely forested with what might be classified as a temperate rain forest. The settlement of the country and lumbering operations have, however, greatly reduced the undisturbed area of timber land. Like our country New Zealand has suffered from the exploitation of her timber with little concern over the conservation of forest resources. The generation that struggles with the problems relating to the clearing of land naturally thinks in terms of the present rather than the future. The large lumbering concerns have meanwhile used the opportunities to exploit the natural resources of the Dominion. The undisturbed forests of this region stand seventy-five to one hundred feet in height and there is a luxuriant growth of ferns and mosses on the forest floor. Tree ferns are common but of smaller size.

The Ohakune district is one of the few points on the main line having at the present time considerable areas of native timber. At one side of the town there are excellent standing forests while on the other side of the railroad are vast stretches of stumpage with hundreds of standing and fallen trees decaying where they grew. The choicer logs lumbered out, the remainder with the detritus is burned, sheep are turned in, and in a short time the forest is a pasture.

This trip afforded opportunity for noting the agriculture of North Island, which offers sharp contrast to that of parts of our country of corresponding latitude. The climatic factors discussed above were shown to favor foliage parts of plants. The evergreen habit is a resultant of such conditions and has dominated their agriculture. In the first place the principal plant product of New Zealand is leaves, though it is chiefly those on herbaceous plants, and takes the form called pasturage. In going from Auckland to Wellington, a distance of four hundred twenty-five miles, I traveled only by day-time trains in order that I might see the country better. I believe my notes give something between stations all the way down to North Farmington and in reviewing these I find mention of one tiny area of corn, one setting of grain, a few fields of pumpkins and numerous fields of turnips. Other than these and excepting of course the limited forests that are seen from the train, the whole country is one pasture, and why not? Recalling that the winters are mild and that the fields can be grazed twelve months in the year, why put up hay at great expense of time and labor when the cattle can better eat fresh grass in the fields? Or why struggle through the summer season producing corn or grain when the animals can do their own harvesting in the pasture any day or night in the year? In other words the grazing lands are the chief agricultural asset of North Island, and this explains why the meat and tallow, butter, hides, and mutton from New Zealand are pushing into every market in the world. It would seem as if these products could be produced much cheaper here than in any competitive land where the climate compels the feeding of live stock during the winter months with hay or grain produced at so great expense.

This relation has been an important factor in the destruction of forests and the conversion of "bush" into pasture. In Ohakune one sees the process now being carried out. Here to-day is a magnificent forest; the lumbermen go through and cut what they wish to take; the slash and forest detritus is burned, destroying the forest floor vegetation and all but the large logs of the fallen trees; then sheep and cattle are turned in and in a short time the forest has become pasture. No special harm is done if twenty years are required for a stump to decay, since this does not interfere with grazing and occupies a relatively small part of the ground. Here again you have a sharp contrast with our ways of clearing forest land, involving the grubbing or blasting of stumps at tremendous expense of labor and money. I was interested to learn that farm values in this part of New Zealand compare favorably with those of the upper Mississippi Valley, their land running up to as much as one hundred pounds per acre.

While there we noted also that the blight which has fallen upon agriculture the world over in recent years had not spared New Zealand. There, as here, the farmers, who are after all the only real producers of material in the world, were suffering greatly in comparison with those engaged in other lines. New Zealand, however, has been more helpful to her farmers than we have been in the United States. By fixing the price of wheat for example, the Government has stabilized the price of this important product and insured a minimum return to the farmer. Meanwhile the government protects itself by its tariff law which prevents other countries from dumping wheat into New Zealand. In other words

Ferns and epiphytes in gymnosperm forest, Ohakune, New Zealand
(See page 291) (Photo by Wylie)

PLATE LII

Hot springs in park at Rotorua furnishing water for the hotel (See page 304)
Large American gold dredge at Hokitika (See page 324)
Coal cars just from the mine, Westport harbor (See page 323) (Photos by Thomas)

the combination of a tariff and a minimum-price guarantee is operated to the satisfaction of the agricultural producer and through this bettered condition, business in general prospers.

The climax experiences of our trip in certain respects were encountered at Wellington at the southern end of North Island. This city which is the seat of the Dominion Government is beautifully located on Cook Strait across which may be seen the mountains of South Island. The town is pressed in by low mountains reminding one of the situation at Juneau, Alaska, where the mountains threaten to push the town into the ocean. This restricted land area promises to be a serious problem as room for expansion seems limited. The broad harbor is large and makes junction between bold headlands with the open waters of the Strait.

As the capital city Wellington has numerous institutions and a considerable group of scientific men in the various fields of government service. We received much help and many courtesies from officials of the government who took great interest in our program. Others have expressed this appreciation but I must mention at least two, Hon. J. Hislop, Under Secretary of Internal Affairs, and Mr. William McDonald, Acting Director of the Museum. Through their invitation we were given laboratory quarters in the Museum building. Only when one is away from home and divorced from all the conveniences of his own laboratory can he appreciate the real help afforded by the use of rooms suitable for looking over and caring for material. We were doubly fortunate here, as we had been also at Suva, and at Auckland, in that we were not only given the comforts of a building but the assistance as well of trained scientists who were fully familiar with the region.

I found a considerable group of botanists associated with the various scientific institutions about Wellington. In the Government Museum, which employs a number of men, is an excellent botanist, Mr. W. R. B. Oliver; Victoria College has Professor Kirk; with the Government Experiment Station are Dr. A. H. Cockayne, Mr. Esmond Atkinson and Mr. G. H. Cunningham; while near Wellington lives Dr. L. Cockayne, the most prominent botanist of the Dominion, particularly in the field of ecology and plant distribution. His latest volume on the "Vegetation of New Zealand" appeared just before we sailed and is indispensable to any one who is interested in the interpretation of the New Zealand flora. Hon. G. M. Thomson who has recently published a scholarly volume on the ''Naturalization of Animals and Plants in New Zealand'' was at the capitol as a member of the legislature then in session. In addition to these one should mention Mr. B. C. Aston, a botanist of achievement, though he would disclaim such distinction, and others connected with forest service of the Dominion, of whom I saw little during my stay because of my limited time while there.

Mr. Cunningham is one of the rising young mycologists of the southern hemisphere, and his colleague in the Experiment Station, Mr. Atkinson, in addition to taxonomic work, uses his artistic skill in making drawings of plants; he is now associated with Dr. L. Cockayne in his studies on the genus *Nothofagus*. Dr. A. H. Cockayne in charge of the Experiment Station is an aggressive botanist and extended many courtesies in my behalf, as did Professor Kirk of the local college. The Acting Director of the Museum, Mr. William McDonald, is not only in close sympathy with botanical work but has a keen and broad understanding of plant life, and through his studies and photographs of plant formations has contributed not a little.

Since my headquarters while in Wellington were in the Museum building I saw much of both Mr. McDonald and Mr. Oliver and shall never forget the many courtesies of these men. Mr. McDonald was untiring in his efforts in our behalf. I prize highly a number of choice photographs of New Zealand plants and plant formations which he kindly gave to me. While a guest in his home I saw several of his paintings, for he is a skilled artist of thorough training. As botanist of the Museum staff Mr. Oliver courteously shared his laboratory with me, offered valuable advice as to the best use of my time, and named the plants brought in from day to day.

From the Museum as a base, numerous excursions were made into the surrounding region. On these trips I was usually fortunate enough to have as companion some one, or more, of the local botanists, and in this way was privileged to get information faster indeed than I could possibly assimilate the facts and names relating to their plants.

Two trips to Lyall Bay, one with Mr. Oliver and another with Mr. L. Cockayne afforded contact with shore conditions. There was a remarkable surf pounding in from the Straits and breaking in great masses of foam on the rocks. In the very midst of these waves were many specimens of their *Durvillaea antarctica.* This alga gets to be nearly ten feet long and presents massive and leathery thalli to the pounding waves. Strangely enough it belongs to the Fucoids rather than to the Laminaria group. The shore was strewn with the dried remains of *Lessonia* plants, many of them very large and strong. Mr. Oliver is at present engaged on some interesting ecological studies involving both animals and plants of the shore margin. His familiarity with both classes of organisms peculiarly fits him for this type of investigation.

Through the invitation of Mr. McDonald of the Wellington Museum I was privileged to enjoy a visit in his company to the home of Sir Pomare, a prominent New Zealand physician and citizen of Maori extraction who studied in America, completing his medical training at Chicago. While a student here he lectured extensively in Chautauqua circuits over the interior of our country. When he learned we were from the Hawkeye state he spoke of his Iowa associations and showed a surprisingly accurate memory of many of the towns in which he had spoken as a young man.

Dr. Wi Maui Pomare has been active as a Dominion Director of medical service with the Maori people of New Zealand, and because of these public services and his activities during the war he was knighted. On this Sunday afternoon Lady Pomare, assisted by her daughter, was pouring tea for a number of their friends who had dropped in for a visit. They showed us many interesting Maori souvenirs and heirlooms so much in evidence about their home. Outwardly a fine modern house the interior is in part decorated with Maori designs of their own painting, and certain rooms are papered with tapa cloth given to Sir Pomare when on a visit in Fiji. Most interesting to me was the fine display of native weapons which had been inherited by Dr. Pomare from his chieftain forebears who had been members of the ruling group in these islands. When Mr. McDonald, a Scotchman, informed Dr. Pomare that I was also of Scotch descent, Sir Pomare, who is of course a Maori chieftain, immediately remarked that he too had Scotch blood in his veins. In explanation he said that according to a legend a century or so ago his immediate ancestors had been around the family board when a Scotch missionary was the central feature of the feast and so he said by inference he must have Scotch blood gained through that experience.

I spent one day as the guest of Mr. Atkinson in the "bush" opposite Wellington. I had wished to see something of these forests in which the *Nothofagus* is prominent and accepted the kind invitation of Mr. Atkinson to spend the day on his extensive tract of timber land running from tide water up over hills to a height of several hundred feet and overlooking the outer harbor. With Mr. Cunningham of the Experiment Station I crossed over on the early morning ferry. We were met at the pier by Mr. Atkinson who lives on that side and we were hospitably welcomed by Mrs. Atkinson to their beautiful home which stands near the border of the forest and on a slight elevation affording a fine view across the water to Wellington. It seems that after the fashion of Americans I had been complaining about some of the things experienced in New Zealand, one of them the total lack of drinkable coffee. They have oceans of tea but no real coffee, so while we were warming ourselves for a moment by the fireside Mrs. Atkinson brought in real coffee which I enjoyed very much.

Thus fortified we then set out up the steep slopes of the low mountain bordering the harbor. Passing up a deep valley with many fern trees and various evergreens we found the beech formation at an elevation of a few hundred feet. This was my first contact with the New Zealand *Nothofagus,* one of the few deciduous trees of North Island. This interesting genus is represented by various species occupying the southern end of North Island and extending all over South Island and Stewart Island. The black trunk is suggestive of our beech and the branching and foliage reminds one also of our *Fagus,* so that their kinship is quite evident.

Late in the forenoon as we worked down the slopes we found Mrs. Atkinson by a comfortable camp fire in the valley. Swinging from a metal tripod was a coffee kettle and in the big basket were the other factors of our fine noon time lunch. With the sun's rays shining warmly into the notch between the forested hills we were so comfortable that we could quite forget that it was midwinter. Indeed with fern trees and evergreen vegetation all around us it was difficult to discover by the eye, at least, that it was not midsummer.

Following the descent we spent a pleasant hour with the Atkinsons in their home, and noticing the many beautiful pictures I complimented him on the decoration of his walls. Noticing over the fire-place a large canvas which was obviously none other than a picture showing the surrender of the German fleet, I suddenly turned on Mr. Atkinson and said, "You painted that picture, and the others as well, didn't you?'' Only then did I learn that he himself was the artist. The further deduction was easy; Mr. Atkinson had been a member of the British navy and I later learned that he had been an officer on duty on the morning of the surrender and had gotten the inspiration and the preliminary sketches on that occasion which later made possible his fine painting. Again illustrating the versatility of those New Zealanders.

In fact the most remarkable feature of New Zealand is its people. An almost pure Anglo-Saxon stock, mainly English and Scotch with some Welch and a slight admixture of Irish they constitute as fine an assemblage of folks as can be found in the world. An officer of the government said that he knew of but one person in the Dominion who did not speak English and that one was the mother of a state employee, an expert in some field, recently brought from Europe for a special service. I frequently made excuse to be on the streets when the schools were dismissed in the afternoon, just to see the flood of beautiful young children thronging those thoroughfares. The streets were crowded with a pure Anglo-Saxon stock such as is no longer seen in America except intermingled in the crowds from all other parts of Europe.

Any one who visits these British Possessions is impressed by their practice of developing botanical gardens, though this term is entirely too narrow to cover the range of their services. In connection with the larger cities they usually maintain more or less formal gardens with many trees, shrubs, flowers and decorative plants. But of greater importance is the fact that through these preserves they seek to protect and cultivate their native vegetation growing either undisturbed or in natural habitat relations. For instance at Suva, in addition to the well planted grounds around the Government buildings, there was an extensive botanical garden carrying a representative display of tropical plants. At Auckland, in addition to the smaller city parks, there was the broad ''Domain'' of several hundred acres with a wide range of forest forms and associated plants. Their new Museum building is to be erected in the border of this area.

So at Wellington one was not surprised to find a very large tract of land near the center of the city, which was far more than a park, in that it was primarily a place for the cultivation and protection of considerable stretches of natural vegetation. Certain portions are devoted to cultivated plants of various kinds and of course such parts are distinctly artificial and primarily intended to display the ornamental plants. These botanical gardens in Wellington have plant houses, offices, etc., and are in charge of a man trained at Kew gardens. I am quite sure that these well developed preserves, parks, and gardens are a very important educational factor in these countries and that we might well develop much more extensive institutions of this kind in our own land.

I seemed to sense in New Zealand a sympathetic interest in America. They are close students of our institutions, and are generously disposed to forgive some things they can not understand. In other words they judge us by our spirit and intent rather than to hold us too strictly to account at all times. If one came to know one of these islanders well there would come a time when with perfect politeness and yet with keenest interest he would ask, "Why did you so long delay your entry into the Great War?" and then, "Why did you turn your back on a needy world as soon as peace was declared?" They feel there must be somewhere sufficient answers, but I, for one, could not make reply to them, for all about me there were wounded men, broken home-circles, and everywhere the scars of their sacrifices.

On the evening of August 15 we sailed out on the Tahiti. I stood on the upper deck until the headlands at the harbor's entrance were dimming in the twilight. Then with an unseen salute to those wonderful New Zealanders I went below and joined Professor Nutting in the stateroom which was to be our home for most of a month. We had good times together and no small part of the value of the summer to me was my close and pleasant associations with the distinguished head of our Department of Zoology.

CHAPTER XVIII

A GEOLOGIST'S IMPRESSIONS OF NEW ZEALAND

BY A. O. THOMAS

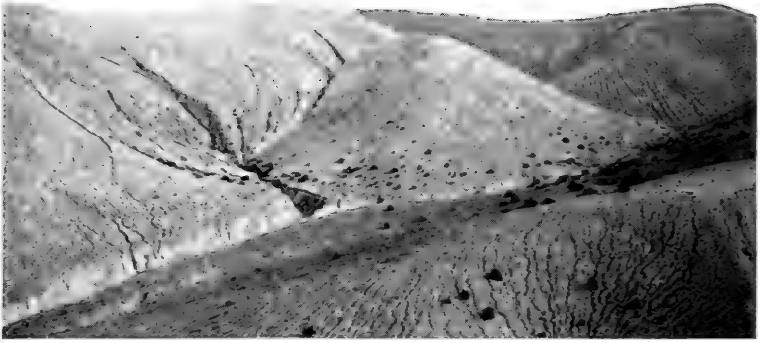
The Dominion of New Zealand with an area of 104,471 square miles, is composed of two large, narrow islands and a number of smaller ones the most important of which is Stewart Island at the southernmost extremity. The distance from North Cape to South Cape is almost a thousand miles yet no point of land is over seventy-five miles from the sea. The islands lie in the open Pacific; their northern extremity, in latitude 34 degrees north, is subtropical, while the southern extremity has long, cold, and wet winters. Invercargill, at the lower end of South Island, with a population 18,000 is the most southerly town in the world having hotels, street railways, parks, and similar improvements. The islands not only have a wide range of climate but have a great variation in altitude extending from marshy lowlands at sea level to the peaks of the southern Alps, some ten or twelve thousand feet high. Rainfall is likewise variable, but nowhere too light for abundant vegetation; in certain sections, as on the west face of the southern Alps, whose crests lie athwart the path of the prevailing northwesterlies, the rainfall is very heavy. A visit in July and August, the winter months, impresses one with the chilly, damp, cloudy weather, a condition that is more prevalent the farther south one goes. In the Dunedin region dwellings are usually provided with stoves, and some provision is made for wintering sheep and cattle. Complaints were heard here of a constant tendency of the population to shift northward to the Auckland district where the winters are more genial.

Geographically, New Zealand is separated by some twelve hundred miles of water from Australia, the nearest land mass. A bathymetric map, based on the soundings of the Challenger and other vessels shows that a large area of land covered by less than one thousand fathoms of water extends for hundreds of miles to the south and east of South Island. On this, for example, lie the Auckland Islands in latitude 50 degrees and 40 minutes south and some two hundred miles from the New Zealand shores. An uplift of twelve hundred feet would connect them with the mainland. There is a similar but narrower shoal west of New Zealand from which a long submarine ridge extends north by west for nearly two thousand miles toward New Guinea. This ridge is less than one thousand fathoms in depth. Between the New Zealand land mass and Australia the sea reaches a depth of over two thousand fathoms.

Geologically, New Zealand is a continent in miniature. Though some of its rocks are very old there is little evidence of its having been a land above the sea before the Jurassic and Cretaceous periods. Since then the area has experienced elevations and subsidences, faulting and folding, mountain-making and vulcanism, erosion by waves, rivers and ice, all of which make a history whose complexity and interest approach that of the greater continental units. Despite the prevailing opinion that the plant and animal life suggest a strong Australian affinity, the absence of the eucalypti and acacias among the plants and of the marsupials among the mammals oppose this hypothesis in part. The various theories based on geological and biological evidences regarding past land connections are many and complicated. Their discussion does not fall within the scope of this chapter.

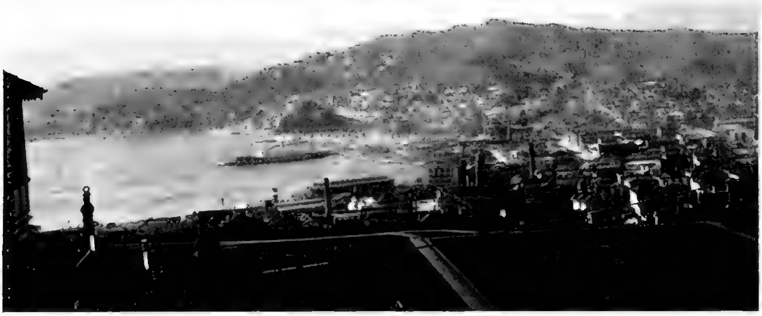
Auckland, the largest city of the Dominion, offered our first introduction to New Zealand. Together with its suburbs it has a population of fully 158,000. It is located at the head of Waitemata harbor whose mouth is guarded by the volcanic island, Rangitoto. Outside is Hauraki Gulf protected by Great Barrier island and the Coromandel peninsula. The topography permits the location of several beautifully situated suburbs among which are Devonport, Takapuna, and Birkenhead, the latter being the home of the plant of the Colonial Sugar Refining Company whose activities are so important in Fiji. Auckland proper is on a narrow neck of land where North Island is nearly cut in two. Onehunga, one of the suburbs, is located on Manukau harbor on the opposite side of the isthmus. It is said that a canal could be readily constructed across the isthmus but for the fact that the tides on either side are not synchronous, and the result would be an irregular and disastrous ebb and flow in the canal.

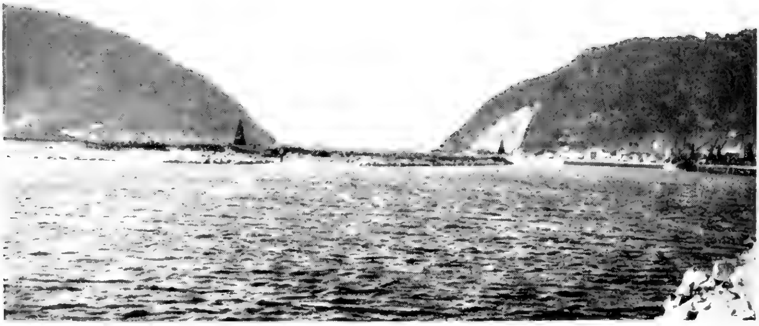
The much-indented coast-line of the harbor is due to the erosion of the region into ridges and broad valleys at a time when the



Volcanic ash mantling hills after the eruption of Waimangu, the world's largest geyser (See page 308)
The Remarkables; looking across the Domain (See page 335)
A road cut through deep loess at Oamaru (See page 334) (Photos by Thomas)

PLATE LIV





Wellington harbor from the hills (See page 315)
Rock arch near Lyall Bay, Wellington, on an uplifted platform following the earthquake of 1855 (See page 316)
Water gap of the Grey river at Greymouth (See page 322) (Photos by Thomas)

land stood higher above the sea than it does to-day. Since then the area has been beneath the sea and a very thick veneer consisting of a succession of alternating beds of soft sandstone, and tough blue clays have been laid down as an estuarine or slack water deposit. Later the region was uplifted but not to its former elevation. As a result Auckland and its environs are located on a region of sharp relief which has been softened and masked by the later deposit known by the Maori as the "papa" rock and by geologists as the Waitemata beds. A knowledge and appreciation of these simple geological relations have greatly modified the general work of harbor development and the reclamation of the low land about the end of Queens street. The "papa" rock is the origin of the fine soils of much of the Auckland peninsula justly famous for its agriculture, dairying, and stock breeding.

In places the Waitemata series is abundantly fossiliferous. Dredgings from the bottom of the harbor excavations yield quantities of molluscan remains which are very well preserved. A small but representative series was collected. Some thin layers are more or less calcareous and contain a wealth of foraminifera. These and other fossils of the "papa" rock have been made famous in a monograph by the Austrian paleontologists, Zittel, Karrer and Stache, of the "Novara" expedition of 1864.

The most obvious geological phenomenon of the Auckland area is the numerous cones of small extinct volcanoes. Rangitoto is the largest of over sixty which occur in the district. The streets and town lots of Auckland have been laid out with reference to these natural features, and much of the landscape effect incident to the arrangement of homes and gardens in the residence districts is due to the cones, lava slopes and ridges of volcanic origin. A pretty eminence of this kind in the southern part of the city is Mt. Eden. At its top is a large crater partly filled with reddish clinkery scoria. Its slopes are a succession of lava-flow terraces. At one point on its flank is an artificial opening whence are removed great quantities of scoria for road metal. The one hundred foot face of the workings shows well the nature of the extrusive material which in certain layers is much like slag. Occasional dikes and sheets of solidified lava tell another side of the volcanic story. In the debris were picked up examples of volcanic bombs of the size and shape of small hand grenades.

On one of the lava-flow terraces in the residence district we dropped into an opening in a lawn and entered an irregular tunnel four to ten feet high. This is but one of many subterranean passage-ways which underlie sections of the city. They are the result of the forward movement of the liquid lava after a crust had formed by cooling on the surface of the flow. In places the floor showed ropy lava, and on it here and there our candles lighted up "whirls" of rudely circular ridges. In one place the floor crust had turned over while yet viscous, in another slow solidification had partly blocked the tunnel, and in still another the roof had fallen permitting a later flow to enter and join the viscous mass below. From the roof hung lava pendants which one learns to avoid after bumping into them once or twice.

Rangitoto, mentioned above, is the largest and apparently the freshest of the Auckland volcanoes. A visit to the cone was made possible through the kindness of Mr. Hamer, chief engineer of the Harbor Board. A fast launch with Mr. Povey as guide quickly negotiated the nine miles of water. The cone rises out of the bay forming a nearly circular island eight to nine miles in diameter and 920 feet high. Approach to the shore is difficult since the jagged edges of the successive lava flows make an irregular saw-tooth coast-line which lacks sheltered bays. From a strongly built wharf a path leads up to the summit. The surface is a succession of strong, clinkery, pressure ridges of broken, porous lava blocks standing at all angles and presenting an all but impassable terrane. In spite of heavy rainfall, vegetation has only a precarious foothold on the unweathered lava. In places large areas of the surface are quite barren, and the black lava, from a distance, resembles a freshly plowed field. On the more abrupt central part the scoria slope offers a more hospitable habitat, and vegetation is more abundant but not dense. On the south slope are two small parasitic cones. Between them and the main cone is a depression, wooded and sheltered; these together with the 200 foot crater, are the main retreats of the nearly wild sheep and wallabies introduced on the island some years ago. The summit yields a good birdseye view of Auckland, its harbor, and suburbs. At the east end of Rangitoto the Harbor Board has established a quarry and a stone crusher for obtaining stone for making moles and for crushed rock in cement work. Sand and gravel are negligible in amount about Auckland, and the "papa" rock, described above, is far too soft for construction purposes. For this reason the Rangitoto quarry is operated on an extensive scale. The face is three hundred to four hundred feet long and twenty to thirty feet high. The hardened flows are vesicular basalt rich in olivene. Intermingled with these are scoria, slag, and clinker. The latter are crushed and screened and yield a filler for concrete, thought to be superior to gravel. More than one hundred men are employed working eight-hour days. They are paid from one shilling tenpence to two shillings sixpence per hour depending on the kind of work they do.

The volcanic rock toward the edges of Rangitoto is quite thin as may be seen at the quarry whose main building is supported on piling driven into the "papa" rock at the water's edge. Apparently the period of volcanic activity is considerably later than the laying down of the "papa" rock although a considerable amount of volcanic ash is interbedded with the clays and sands of that formation. In places its evenly laid strata are sharply folded and occasionally faulted by the thrust of the penetrating lavas.

Across a shallow narrow strait from the Harbor Board Quarry is the island of Motutapu composed almost entirely of a pile of the Waitemata beds left as an erosion remnant. In a rubbly fossil-bearing zone near the water level is found the remains of a giant Tertiary cirripede, known as *Scalpellum aucklandicum.* We were fortunate in securing a few of the plates of this rare barnacle.

THE ROTORUA LAKE DISTRICT

On July 15, my aide, Mr. Glock, and I left for the hot lakes and geyser district at Rotorua. Through Mr. Wallnut of the Government Tourist Bureau we had purchased transportation good on all railroads, lake boats, and mail-carrying automobiles connecting or extending rail terminals. These tickets, costing £16-5-0 each, were good for sixty days, first class. They proved a great convenience for as we were in a sense guests of the government, our movements were anticipated, and we found someone at every point ready to receive us and direct us how to make the best connections, find suitable hotels, or see such geological phenomena as we had come to study.

The Waikato valley south of Auckland is a rich district in which dairying, grazing, and the growing of small crops are the chief industries. Butter, cheese, and other milk products from this valley form a goodly part of the six million pounds' worth annually exported from the Dominion. Milking is largely done by machinery and the products are collected in large lorries daily. At Hamilton there is an extensive Agricultural Experiment Station which compares favorably with those in the States. The divide between the Waikato and Thames is in places a low intractable peaty marsh overgrown with ti trees. The higher land is being cleared of native timber for grazing. Here and there the Australian gum trees have become established in place of the short tree-ferns and rimu, while many clearings are overrun by the Scotch gorse, a thrifty yellow-flowered shrub, which makes impenetrable thickets. This fast-growing invader is becoming a pest. It is said that the first bushes brought from the mother country were planted with religious ceremony by the homesick settlers! The lava plateau is reached at Mamaku although considerable volcanic ash is apparent in railroad cuttings on the way up.

Rotorua is situated on the shore of a lake of the same name in the midst of a region filled with hot springs, fumaroles, boiling mud pools, and small geysers. The air is noticeably charged with hydrogen sulphide; one's watch case turns black, and even coins in one's pocket lose their luster. Some of the thermal springs are particularly rich in minerals, and well-equipped, curative baths are extensively patronized by those seeking relief from various ills. The sanitarium and spa buildings are attractive and well constructed. The Maori villagers of Ohinemutu on the shore of the lake cook their food and wash their clothes over natural steam holes. In a little cemetery near by a vigorous hissing steam vent issues out of a tile set between two graves. It is hoped that the situation casts no reflection on the departed. King George V Hospital is situated on a ridge near by. It was here that many convalescent soldiers were so beneficially treated by the hot mineral waters during the late war.

Whakarewarewa, or just Whaka for short, is the site of an old crater basin about a mile out of the city. This area is filled with hot pools, hissing steam vents, and boiling mud pots. This was the home of a very vigorous geyser, Waikite, which became inactive twenty years ago except for one dying eruption a few months previous to our visit. Its terraced cone of grayish white sinter intermingled with yellow sulphur still harbors a series of hissing, sputtering steam vents. Pohutu, Wairoa, and Papakura are other geysers of greater or lesser reputation. The place is crowded with solfataric action of every sort.

Lake Rotorua, six or seven miles in diameter, is but one of a dozen of more large lakes in the district which occupy old explosion craters or depressions dammed by lava flows. Near the center of the lake rises the conical island of Mokoia which reminded us of Wizard island in our Crater Lake and its origin is doubtless similar. Besides the water-filled craters there are several rim-broken, drained depressions—doubtless old craters—and also many hills of volcanic origin culminating in Moerangi (2440 feet) and Ngongotaha (2554 feet).

THE TARAWERA ERUPTIONS

Fifteen miles from Rotorua there is another much visited region made famous by the eruption of Mt. Tarawera (3770 feet) on the morning of June 10, 1886. This flat-topped eminence standing some 2500 feet above Lake Tarawera near its base had never shown any signs of activity. A few miles to the southwest of the sleeping giant lay a geyser basin larger than that at Whakarewarewa and justly famous for its magnificent Pink and White Terraces similar to those of our Yellowstone Park. On the night referred to after a few premonitory rumblings and earthquakes, the mountain split in two, the fissure continuing down its southwest face through Lakes Rotomakariri and Rotomahana to the geyser basin. The rent was eight and three-fourths miles long with an average width of forty rods and a depth from nearly a thousand feet in the mountain to some three hundred feet at the south. The fissure, still largely open, is the most awesome on the face of the earth. During the eruption an enormous quantity of fragmentary material was ejected mainly in the form of fine dust, but in the vicinity of the fissure there was much coarse material, the heaviest blocks weighing as much as eighty tons. The roar of the explosion was terrific, and the steam was lifted nearly three miles into the air. The result was a large pit over 500 feet in depth at whose bottom was a violently boiling lakelet. Since then the pit has filled with water, making the present Lake Rotomahana, four miles long and two miles wide. It is 520 feet in depth and covers not only the area of the two small lakes mentioned above, but also the sites of the beautiful Pink and White Terraces, now far below the surface, and much of the former solfataric basin. Many hot springs and geysers issue beneath the lake near its northeast shore, and the whole side of the Rotomahana crater in this area is alive with roaring steam vents. The lake water has a greenish color and in places is too hot for the hand. The surface of Lake Rotomahana is 148 feet above that of Lake Tarawera, and the two are separated by a narrow strip of land. Our Maori guide, Patiti, suggested the possibility of draining the former into the latter at least to the extent that the sites of the terraces be exposed hoping thereby to uncover them by hydraulicking, in case they were not destroyed by the original eruption. Moore and others, however, report that fragments of terrace sinter occur with the coarser ejectamenta of the vicinity. This Patiti strongly denies. In our opinion the removal of the water load from the solfataric area of the lake is frought with dangers from new explosions which might well be of disastrous extent. The balance is delicate as will be seen later on. The eruption of Tarawera lasted for several hours; in fact the general disturbance lasted for several days. Hector and Park who visited the scene on the 13th and 14th mapped no less than seventeen points of active eruption along the fissure. A strong wind from the southwest scattered the finer debris over the country and out into the Bay of Plenty. It covered an area of some 6,000 square miles, one-fourth of which was damaged for agriculture. Moore estimates that from 520,000,000 to 620,000,000 cubic yards were thrown out. All inhabitants within four miles of the mountain were killed. In all some 130 persons were lost, most of whom were natives. Several villages were completely buried by the fine gray blanket which destroyed all life and covered the immediate region with upwards of fifty feet of ash and scoria. This depth rapidly grew less away from the foci of eruption until at a distance of a few miles, vegetation was able to re-establish itself promptly; but in the nearby area it was some years before trees and ferns gained a foothold, and even now there are large barren tracts in spite of the abundant rainfall. The layers of ash mask the original surface on which they rest. In places rain has eroded these into deep sharp-sided gullies and ridges, revealing here and there the old soil and charred wood below. Much of the debris has been washed to lower levels and into the lakes. We were told that this sediment plus that which fell into Lake Tarawera raised its surface permanently forty-two feet at the same time adding much to its area by overflow of the bordering low lands. Apparently all life in the lake was killed, but it is now abundantly stocked with trout.

Professor Park, mentioned above, and who was our genial host at Dunedin, has written most interestingly about the great eruption of the latter stages of which he was an eye witness. Liberty is taken of quoting a few passages.

> "The premonitory signs of the coming disaster consisted of subterranean rumblings and earth tremors lasting several hours; but whether these were of such a nature as to cause anxiety or alarm to those living near Rotomahana and Tarawera is unknown, since all the native villages within a radius of four miles were destroyed, not a soul escaping. It is, however, certain from the evidence of the survivors at Te Wairoa, situated on the west side of Lake Tarawera, that the titanic outburst which split Mount Tarawera in twain from end to end and opened the yawning fissure that stretched southward for miles over the low plateau near Rotomahana, took place with appalling suddenness. For a space of four hours, the craters situated on the line of the newly formed rent poured out piles of ash that overwhelmed the whole country, which, as far as the eye could reach, was converted into a weird gray-draped smoking desert.
>
> "After this, the violence abated; and at the time of the author's visits .... the vents on Mount Tarawera, at Rotomahana, Black Crater, and Echo Crater were centers of great activity, from which clouds of andesite boulders were projected high into the air, some being shot over the crater-rim, where they were piled up into confused masses, others, and apparently the majority, falling back into the throats of the vents, where they were churned up by the escaping steam until again tossed out. The steam issued from the vents with a terrific continuous roar; and the descending blocks of rock struck the ascending masses with shattering violence, the united effect being stupefying and overpowering. At short intervals that rarely exceeded twelve minutes, there took place, heavy underground bumps—such as might be caused by subterranean explosions. These were instantly followed by short, sharp earthquakes of such violence that it was, after a time, deemed advisable to withdraw to the vicinity of Black Crater..........
>
> "The effect produced on those witnessing this grand display of plutonic force at short range was diverse. At first some became hysterical, but in time all relapsed into a subdued mood of indifference followed by a stupefying languor. It is not improbable that the stupor was caused by the presence of carbon monoxide in the gaseous emanations of the craters" .... (James Park, *The Geology of New Zealand,* 1910).

Our Maori guide, Patiti, who has lived in the region all his life, was a young man at the time of the eruption. He is an intelligent, unassuming gentleman. His English name is Warbrick. His home is on the shore of Lake Tarawera opposite the now sleeping mountain. He showed us the site of several of the overwhelmed villages, in one of which he lived in 1886. Fortunately he was acting as guide to some hunters, and at the time of the eruption they were camped in a slab hut a few miles away but in full view of the mountain. His story of the event is here given, much as it was taken down while we were crossing Lake Rotomahana in his fine launch.

"We were awakened about 2 A. M. by a tremendous roaring noise. Outside was a weird light from the reflection of the steam cloud lighted up by the hot rocks in the cleft. The cloud looked like a pillar of steam. The roaring and rumbling became ceaseless. The earth swayed and vibrated, while the most vivid and unearthly lightning flashes lighted up the great pillar and bellows of incessant thunder of deafening power mingled with the mountain explosions. Ashes began to fall and now and then a heavier thud on the roof could be heard above the din. But it was mostly a quiet shower due to the grander and more terrific display a few miles away. Breathing gradually became difficult due to the dust and gases. It was necessary to keep hold of something to be able to stand; death seemed imminent. We four lived in the hut on some scanty provisions for three days, finally escaping through the roof. Eleven feet of ashes had fallen and only the incessant rain during the first thirty-one hours which had packed the ash, made it possible to get away."

THE WAIMANGU AND TAUPO BASINS

At the west end of Lake Rotomahana is a valley leading up to the famous Waimangu Basin. Its entire course for about a mile is a succession of fumaroles, hot springs, and "dry-mouthed" geysers. The fumaroles emit a variety of gases, some of them dangerously hot. Such local names as Paddlewheel geyser, Devil's Kitchen, the Inferno, and similar designations indicate the character of the place. In the midst of this thermal aggregation, there broke out in 1900 a world famous giant geyser called Waimangu. It played more or less intermittently until in 1908, sending at intervals an enormous column of water and mud to a height of fully 1200 feet. From the floor of the mud pool, it erupted first at one end and then at the other generally straight up into the air but at times obliquely and at any angle; at such eruptions it plastered the hillsides with mud, sand, and even boulders. This made close approach dangerous. The hills in the vicinity are still gray and but little covered with vegetation due to these strange bombardments and others to be mentioned later. Rain has carved the hill slopes into an elaborate network of gullies extending from top to bottom.

Above the site of Waimangu is an area known as Frying Pan Flats, so called because by hydrothermal action iron sulphide is deposited on loose stones as a bright yellow film. The upper part of the flats is occupied by a deep hot pool, which originated at the time of a violent eruption in 1917 which destroyed without warning this part of the Frying Pan only a few hours after a party had leisurely walked over its floor. At the time enormous quantities of brownish mud were thrown over the nearby hills, and the concussion blew the roof off the Accommodation House several hundred yards away. Unrestored parts of the house are still weighted down with tons of mud. Two persons taking refuge in the house were so badly gassed and injured that they died a few days later. This explosion left a small lake above the site of old Waimangu. In 1919, Mr. Warbrick, our Maori guide at Tarawera, blasted away the outlet of the new lake hoping that by lowering the water he might start a geyser at the lake site. The result was a terrific explosion at the upper end of the basin as the water drew off. Mr. Warbrick luckily escaped injury. Mud, this time of a gray color, was thrown out in large quantities, covering a part of the brown mud of 1917. In places gullies have cut through both revealing the Waimangu muds of 1900 to 1908. The view from Accommodation House past sleeping Waimangu and the Paddlewheel across Rotomahana Lake to the heights of Tarawera is an imposing one. Here is a strip five miles long studded with thermal activity and in it a chasm in places 1000 feet deep. It extends beyond the mountain three and one-half miles more, making it, as said before, the greatest cleft of its kind in the earth's surface.

Forty miles from Waimangu is Lake Taupo the largest body of fresh water in New Zealand. It lies in an old volcanic crater, or in a combination of craters, and there is a region of hydrothermal activity at Wairakei near its outlet. At the time of our visit in 1922, a series of perceptible earthquakes lasting for several weeks shook the region. Beyond Lake Taupo and in a line with Rotorua lies Tongariro National Park in which are located the volcanic cones of Ruapehu, Ngaurohoe, and Tongariro. The first is a quiescent volcano of imposing proportions; its snow-clad summit rises a full mile out of the plain; its ice-filled crater one mile in diameter is dwarfed when compared with its circular base, forty miles in circumference. The second is a perfectly symmetrical cone rising 7500 feet above the sea and it is in more or less constant volcanic activity. Its products, however, are harmless ash showers and great clouds of steam and sulphurous gases. The third, Tongariro, is lower than the others and is in fact but the stump of a once much higher cone whose top has been violently blown off.

Out in the Bay of Plenty, far to the northeast, lies White Island, the summit of a very active volcano. A line drawn from White Island to Ruapehu passes through Rotorua, Tarawera, Waimangu, Taupo, and Ngauruhoe. This is the line of the great Whakatane fault. Activities such as the Tarawera eruption are accompanied more or less by sympathetic activities along its entire course. It has been called "the safety-valve of New Zealand", and at intervals for hundreds of thousands of years, volcanic phenomena like those described at Tarawera have been going on along this line of weakness. At times they eclipsed even that majestic display when in addition to paroxysmal outbursts on a titanic scale great sheets of lava were extruded one after another.

WANGANUI AND THE PLIOCENE FOSSILS

Wanganui, located on the west coast one hundred miles directly north of Wellington, is a progressive city of some sixteen or eighteen thousand people. It claims to be the fifth largest city of the Dominion. It is situated near the mouth of the Wanganui river which is scarcely deep enough for ocean-going vessels, but navigable by lighters to large steamers; a brisk export trade in wool, frozen meats, butter and other dairy products is carried on. Efforts to deepen and enlarge the harbor are in progress. The city is built on a low plain, quite above tide, on which are remnants of a terrace. The business district on the right bank is substantially built and has paving and electric tram lines. A number of well constructed bridges give access to the left bank which is higher ground occupied by a very beautiful residence section. The highest part, known as Durie's Hill, is reached by a lift in a shaft 216 feet high which is at the inner end of an electrically lighted concrete tunnel over 700 feet long, opened at the level of the main bridge. From a tower at the top of the lift one gets a fine view of the river and city. A clear sky and a good field glass permit a view of Ruapehu to the north, Egmont to the northwest, the Taraura range near Wellington to the south, and

D'Urville Island across Wanganui Bight, eighty miles away.

At a commanding point on the right bank and on a remnant of a higher terrace is located the Sargent Art Gallery, said to be the best in New Zealand. There is a small but well kept museum, fine schools, an astronomical observatory, and the town boasts a philosophical society with a very creditable list of publications.

West of Wanganui along the coast are a number of outcrops of highly fossiliferous Pliocene beds. The publications on these are well known, and the writer's hope of making collections of the fossils was not in vain. In company with Mr. R. Murdoch, a local geologist of some repute two of the outcrops were visited. At Castlecliff the beds are gray to bluish in color, fine-grained, pumiceous, and slightly micaceous. They are quite soft and as a result the shells can be removed with a strong knife blade. The beds dip to the southeast and the 75-foot "cliff" is at the landward edge of a wave-cut terrace. Huge blocks of the formation are undermined and later destroyed by the waves. These are the bonanzas from which scores of fine shells were dug. The fauna has a high percentage of modern species, but to the northwest as older beds rise the proportion of extinct species is greater and greater. The fauna is largely molluscan but there are a few brachiopods, bryozoa, barnacles, and sand-dollars. The shells are very brittle but by leaving them in the matrix and packing carefully they withstood their long journey remarkably well. They preserve the most delicate markings and make a fine group for study. At Kai-Iwi, farther north, is a higher cliff than at Castlecliff, and the fauna is slightly different. A busy day here with Mr. Murdoch yielded a lot of fine specimens to which our genial guide added several from his own collections, a number of which were not found by us at either locality.

On top of the Pliocene bluffs and separated by an unconformity are from four to ten feet or more of a peaty deposit thought to be of Pleistocene age. Landward from the cliff are at least three series of terraces and remnants of a fourth which tell of the upward movements of the region, and there are evidences such as the Pleistocene peat bogs and others to show opposite movements at times. The shore in places is a mass of shifting dunes whose sands are derived from the easily destroyed Kai-Iwi beds. Some of the shore drift sand is black and is derived from the Egmont lavas, ground by the waves and drifted along by the prevailing northwesterlies. The shore cliff continues northward, shutting off the towns of Patea, Hawera, and others from easy access to the sea.

MOUNT EGMONT

Rising sheer out of the Taranaki Plain and dominating the region is Mt. Egmont, an extinct volcanic cone 8,260 feet high. Its symmetry rivals the famous Fujiyama of Japan and like it is beautifully simple in form and all the more striking to behold because of its isolation. In winter Mt. Egmont is coated with snow and makes a most beautiful sight visible from long distances and from far out at sea. The foot of the mountain is heavily forested with ratas and pines while the undergrowth of ferns and other cryptogams is extremely dense, and the branches and trunks are loaded with numerous epiphytes and delicate filmy ferns. Foot paths and drives in the lower forest from which an occasional glimpse may be had of the snow-clad mountain are very charming. Above the forest is a belt of scrub, then one of tussock and finally moss. Above the 5000-foot line reddish scoria and black lavas continue to the summit, but they were quite covered with snow at the time of our visit.

We reached Dawson Falls House, an accommodation hotel maintained by the government at the foot of the mountain, by motor from Stratford, eighteen or twenty miles away. It was July 21 and 22, the weather was decidedly cold, and there was a chill damp wind blowing in from the sea. On our first day the mountain was swathed in clouds, and dense mist forbade our going beyond the established track through the wet brush. However, we reached the black scoria of Manganui Gully and made a side trip onto a sharp ridge designated ''Magnificent View'' hoping the mist might lift, but except for the feeling of being in a dense drifting cloud through which we could seldom see fifty feet, the climb was fruitless. An excellent hot supper and an evening by a roaring fire revived our spirits.

The next morning broke bright and clear. The air was crisp and frosty, and there was no wind. The east was crimson, wine, and gold, and the view of the dazzling white mountain reflecting the rays of the rising sun was unutterably glorious. It reminded me of a similar sight over the Pitons of St. Lucia in the West Indies four years before. The white-robed Egmont, however, was more luminous than the dark-green Pitons, but the sky effect surrounding the latter was more colorful. After a light breakfast, and armed with Swiss ice-axes, smoked glasses and Alpine ropes, we struck the trail. Occasional glimpses of the mountain, now crowned at times with a halo of wispy mist, reassured us that the morning would continue clear. Once when going through the scrub, a cloud closed in about us with the accompanying halos and "spotlights", and a little later a stratum of clouds closed in below us shutting off the forest and plain and leaving us alone with the mountain. Climbing over the scoria was tiresome, but the snow was hard and firm. In a few places steps were cut with the ice-axes largely as a matter of precaution and lest the mountain become engulfed in clouds and fog, a few landmarks were thrown up at intervals as possible guideposts on our return. Three hours after the start we reached Fantham's Peak, a parasitic cone, some distance below the summit. Progress beyond this point was deemed unwise, for there was above us a heavy fall of loose snow. With our glasses we could see the snow drifting about the dazzlingly white crest from which protruded the black "Shark's Tooth", a bit of the edge of the crater's rim, silhouetted against the blue sky.

A view of Ruapehu and his companions on the Waimarino plain nearly one hundred miles away was clear and distinct; through the field glass, the darker gullies on the slopes of Ngauruhoe simulated great flows of fresh lava. Just below, the plain of Taranaki dotted with farmsteads and villages was a pretty sight and alone well worth the climb.

Egmont's base is broad and its flows extend far out on the plain and to the sea on three sides. They have added perceptibly to the land area of North Island and the weathered andesite rock makes a fertile soil. Geologically, Egmont like Ruapehu dates back to the late Pliocene, and both are older than the lava cones about Auckland. The low Pouakai Range on the northwest flank of Egmont is thought to be more or less contemporaneous with its latest eruptions, but the Kaitaki Range of hills between Pouakai and the coast is considerably older and is correlated in age with the striking Sugar-loaf hills of New Plymouth. The immediate vicinity of Mount Egmont is directly exposed to the moisture-bearing winds, and it receives a rainfall of close to one hundred inches annually. The numerous streams radiating down from the mountain attest this heavy precipitation, and since they are fed by the melting snow a high percentage of them is permanent. However, little or no snow is carried over from year to year.

It is gratifying to know that the Egmont area has been made a reservation with hotels and guides for tourists under government supervision, and a wise policy of conservation of its natural beauty, we were told, has been adopted. With the mountain top as a center, a circle with a radius of six miles has been drawn, and along this circumference, a road has been established; several well kept roads lead from this periphery to convenient points and rest houses nearer the base of the cone whence ascent is begun on foot.

The Taranaki district because of its heavy rainfall is better adapted for dairying than for sheep farming. Dairy factories are numerous, and their products are famous. The land is nearly all in small holdings, and large sheep runs common elsewhere are absent. This makes for a denser population with the accompanying advantages; one of them worthy of special mention is the fine roads of the district partially maintained by a system of tolls collected every few miles along the way. These remarks are not meant to cast any reflection on roads elsewhere in New Zealand; in fact, it was a source of constant surprise to find such uniformly good roads in so new a country with an average population density of only ten or twelve per square mile.

WELLINGTON AND ITS ENVIRONS

Wellington, the capital of New Zealand, is located at the southern extremity of North Island. Its latitude, 41°17′, is almost the same as that of Iowa City except that one is south and the other is north. It has a population of about 103,000, and besides being the seat of government it is the location of Victoria College, beautifully situated on the hills overlooking the city and harbor. The new Parliament building is architecturally attractive, being constructed of very pleasing types of granite and marble transported from the north end of South Island, just across Cook Strait. The Town Hall is another fine edifice, and the business district is substantial and handsome. The place has an air of prosperity, and there is a large volume of business. Lambton Quay, the main street, is no longer the quay but is now separated from the harbor by a considerable area of ground made by filling in the shallower water of the harbor. This new ground has become the source of considerable revenue to the Harbor Board, since on it are built many of the city's fine business blocks. The residence district is spread over a series of steep-sided hills which rise rather abruptly from the strip of shore on which is built the business district. This hilly situation has required the development of interesting engineering undertakings in connection with city water supply, sewage disposal, tunnels for roads and railways, cable tramways, and many other features. A very fine wharf of reinforced concrete, a patent slip for vessels, and many other harbor developments are worthy of notice.

To the geologist, the most interesting feature of Wellington is its famous land-locked harbor and its origin. The harbor, known as Port Nicholson, is a body of water with an area of twenty-five to thirty square miles whose maximum depth is about one hundred feet. It is entered through a neck four or five miles long and but one mile wide at its narrowest point. On all but one side it has many sheltered bays, of which Lambton Harbor and Evans Bay, about which Wellington is built, are the finest. The total shoreline inside of Point Dorsett is here estimated at fully forty miles. There is but one island of any consequence within it. It has been frequently said that all the navies of the world could easily anchor in Port Nicholson and the statement is fully justified.

Port Nicholson is the result of local subsidence, the northwest side of the depression being a fault scarp and almost a straight line. The history of the movements and the development of the resulting shore features have been worked out so masterfully and in such elaborate detail in several papers by Doctor Cotton of Victoria College that only the more apparent features are noted here.

The city of Wellington is located along the southwest shore of the depression, and the southwest end of the fault dies out in the hills back of the city, while its northeast extremity extends far up the Hutt valley. The embayed cliffs along the southeast shore of Port Nicholson converge toward the fault scarp at such an angle as to intercept it at Upper Hutt or thereabout some eight or ten miles above the upper end of the harbor. This narrow triangular fault valley with its apex at Upper Hutt and its base at Petone has been aggraded by the slow encroachment of the Hutt delta. A considerable amount of sediment doubtless covers the entire floor of the harbor mantling and smoothing the warped-down surface, which is thought to have had considerable relief. A contour map of the bottom shows a rapid drop to deep water along the escarpment of the northwest shore, and as a rule a much more gently sloping floor elsewhere.

Evidences of tilting into the depression are many and interesting. The general structure of the Wellington peninsula runs north-northeast, and the major streams are adjusted to it. As a result, the streams east of the Port Nicholson depression lie in valleys which are more or less parallel to the axis of movement. However, the headwater tributaries which enter the Wainui-o-mata from the west and northwest show remarkable aggradational effects due to headward tilting. Moreover, the streams entering the sea between Cape Turakirae and the harbor entrance are progressively more and more drowned at their mouths as the harbor region is approached. Indeed, there is a small lake at the mouth of each of the two major streams nearest the entrance. The headlands on this strip of coast retain a series of benches which are the remnants of elevated wave-cut rock platforms. These benches tilt toward the Port Nicholson depression at the rate of about 175 feet per mile. If this endwise tilt is a measure of the amount of warping, and if the area involved extends from the fault scarp across Port Nicholson to the valley of the Orongorongo river—a distance of ten miles—then the maximum downwarp should be in the neighborhood of 1750 feet. Doctor Cotton has placed it at fully fifteen hundred feet.

In 1855, there occurred a remarkable uplift in the Wellington area. It was accompanied by a severe earthquake such as would be highly disastrous were it to occur in the same region now. While the amount of uplift was not sufficient to change the shorelines materially, minor effects and the subsequent changes they have suffered due to the various agents of erosion can be accurately studied under conditions where the time element is known.

A few of the more obvious ones studied during the brief time available to us may be mentioned. The shores south and southwest of Wellington previous to the uplift were cliffed, and broad wave-cut platforms had been developed. The latter are now exposed; on them are several stacks out of reach of the present waves, and at the bases of the cliffs are ancient sea caves and arches. The narrow isthmus separating Evans and Lyall Bays is a low strip of sand tying Miramar peninsula (that was "Miramar Island" previous to 1855) to the mainland. Raised beaches well out of reach of storm waves are common, and the streams flowing down the steep fault scarp were quickened, and some of them now empty out of small hanging valleys.

The country northeast of Wellington is reached by a railroad which passes up the Hutt valley through the thriving town of Petone, where we had an opportunity of visiting the large woolen mills. Over four hundred persons are employed, and the chief products are blankets, tweed cloth, and rugs. The Hutt delta plain, on which Petone is located, is the largest area of flat land bordering on Port Nicholson. In early days the pioneers contemplated establishing the harbor town on this level area. But the strong northwest winds swept the upper end of the bay and the sailing vessels were forced to seek shelter in the coves which are now Lambton Harbor, thus determining the site of the future capital. The railroad continues up the Hutt valley and across the Rimutaka range over which the winds sweep so fiercely that shelter sheds have been erected over the road for protection. Trains are drawn over this part of the line by two powerful engines using a third rail where the incline for three miles is one in fifteen. Here we entered the rich Wairarapa district, one of the wealthiest sections tributary to Wellington, and beyond it is the famous "Forty Mile Bush", a prosperous dairying and grazing area with tremendous future possibilities, for when placed under intensive cultivation it will support a dense population.

COOK STRAIT AND NELSON

A night's voyage in a crowded two-hundred-ton boat, the Nikau, brought us from Wellington to Nelson at the head of Tasman Bay in South Island. The trip was decidedly rough, and there was little sleep. It is scarcely twenty miles from land to land in direct line but to reach Nelson it is necessary to go into the open sea and to enter French Pass between D'Urville Island and the mainland. Cook strait is proverbially windy for it lies in the path of the westerlies, or the "roaring forties" of the seaman, and the neck of the strait is at the apex of a great funnel whose mouth is between Cape Farewell and Cape Egmont.

A favorable morning tide bore us into the harbor while Orion was still brilliant in the northeastern sky and the Southern Cross hung inverted in the west.

Cook Strait is on the line of one of the major faults of New Zealand, and not only has there been a depression and a remarkable dislocation along the straits region but, according to Dr. Park, "North Island has been thrust eastward some distance relatively to the South Island." At nearly right angles to this fault extend the Whakatane fault, mentioned in connection with the volcanic phenomena of North Island, and the Wairarapa fault along which earth-rents could be traced for many miles on both sides of the strait during the earthquakes of the fifties. At Nelson the southern end of the Whakatane fault has brought the coal-bearing Miocene beds against the Triassic.

Nelson is an attractive town of ten thousand inhabitants. The surrounding region is noted for fruit-growing, and we saw here some of the largest orchards and berry patches in New Zealand. The place is famous for its jams and preserves which find a ready market throughout the Dominion. The climate of the region is remarkably mild with a rainfall of close to thirty-six inches and an average of three hundred sunny days per year. The harbor, Nelson Haven, lies behind a natural mole of coarse gravel and boulders. The material is of glacial origin heaped up as a result of the opposing action of strong heavily laden post-glacial streams and powerful ocean currents driven into the bay by the prevailing winds. This Nelson Boulder Bank, as it is called, is a very conspicuous physiographic feature, especially at low tide.

GENERAL FEATURES OF SOUTH ISLAND

South Island has an area of 58,525 square miles, being a fourth larger than North Island and a little larger than the state of Iowa. Its length is close to five hundred miles, and its mean width is about one hundred miles. Its population—close to half a million—is but about two-thirds that of the warmer North Island.

The great Southern Alps extending parallel to the western coast from Tasman Bay to the fiords of Otago are a magnificent chain of mountains ranging from six to ten thousand feet in height. They form a narrow snow-clad barrier for four hundred miles and in places are as sharp as a tent ridge for scores of miles. West of Canterbury for over two hundred miles the crest is barely thirty miles from the sea. Many streams flowing down the well-watered, western slope have an average gradient of approximately three hundred feet per mile. Scores of towering peaks culminate in Mt. Cook (12,345 ft.), Mt. Tasman (11,400 ft.), Malte Brun (10,400 ft.) and Mt. Sefton (10,300 ft.). To the south are Mt. Earnslaw (9,100 ft.) and Mt. Aspiring (9,900 ft.). In the vicinity of the latter peak in latitude 44°20′ the main divide breaks up into a number of ridges which spread fan-wise to the south and southwest. On the plains east of the Alpine chain are a number of parallel ridges much lower and more worn. The boldest of these are the Kaikoura ranges of Marlborough, averaging eight thousand feet in height and are apparently a continuation of the Taraura range which forms a part of the main divide of North Island. The subsidiary ranges of the plains as well as the Southern Alps are made up of folded rocks of late Paleozoic and of Mesozoic age.

West of Dunedin in Otago is a broken plain made up of a series of gigantic worn-down block mountains. They show excellent examples of horst and graben structure, the uplifted portions being broad plateaus and the sunken areas making flat-bottomed basins, some of the latter being filled-up lake basins. The block mountains are thought by Park to be "uplifted portions of a maritime base-level of erosion."

The Canterbury plain south of the Kaikouras comprises the hinterland of the city of Christchurch. It is alluvial in origin and covers an area parallel to the coast, roughly forty miles wide by one hundred and fifty miles long, and slopes gradually to the sea from a height of fifteen hundred feet at its western edge. This plain is very valuable farming and grazing land, and it supports a prosperous people.

The so-called cold water lakes of the southwestern part of South Island lie in overdeepened valleys gouged out to great depth by former glaciers and whose outlets have in some cases been blocked by glacial moraine dams. Their floors in many instances have been cut below sea-level while their surfaces are upwards of a thousand feet or more above the sea. Their depths in proportion to their other dimensions are therefore exceptionally great. In shape each tends to be linear and corresponds to that segment of the valley whose deeply gouged bed it occupies.

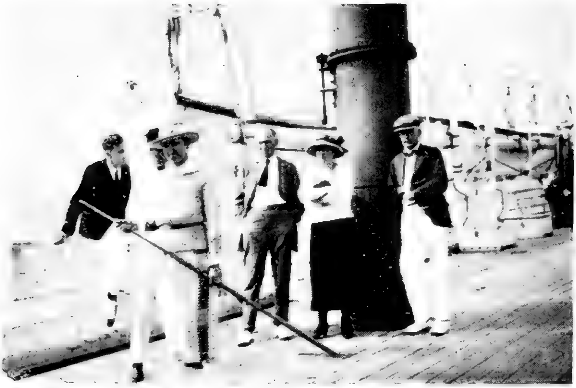
Good examples are Lakes Wakatipu, Manapouri, Te Anau, and Monowai. The famous fiords of the same part of South Island occupy deep, steep-sided valleys whose lower reaches during the Ice Age were gouged far below sea-level, thus permitting arms of the ocean to enter for some distance into these deep narrow embayments. So abundant and picturesque are the fiords of the region that the place is spoken of as Fiordland, and its rugged scenery vies in grandeur with that of the fiord coasts of Norway or Alaska. Milford Sound is one of the best examples. It is fully one thousand feet deep and its walls are sheer precipices two or three thousand feet high. Into these sounds leap waterfalls plunging several hundred feet from the mouths of hanging valleys on the sides. Waterfalls of other origin occur in the region among which may be mentioned Sutherland Falls, near Lake Ada, whose waters drop a distance of 1,904 feet, making it one of the highest in the world.

THE BULLER GORGE

At Nelson we boarded a twelve-passenger Cadillac for Westport, nearly one hundred and fifty miles away. This all-day drive through winding valleys set in primeval forests and flanked by bold hills and farther back by snow-capped mountains is one of the finest imaginable. For many miles there is a steady climb past the Nelson orchards and through sheep runs. The roadbed is well kept but is narrow; in places there are sharp hair-pin turns with a drop of hundreds of feet on the outside of the curve; in others there are great cuttings through coarse boulder ridges and edges of terraces in which the unusually coarse gravel and boulders tell of the powerful currents of the glacial and post-glacial streams. In places valley walls rise to two thousand feet at a slope of eighty degrees, but half this height and a slope of thirty to fifty degrees is more nearly the average. Frequent bridges over turbulent tributaries, immense overhanging rock masses, shelves cut into the living rock just wide enough for a narrow road bed, and the deep forest, here and there scarred by a swath-cutting landslide, contribute thrills and variety to this remarkable forest road. This is the gorge of the Buller river, an antecedent stream which has cut its remarkable canyon through recently uplifted mountain blocks. Between the blocks there are miles of flatter land where the valley widens and where man has made small settlements.

Highly fossiliferous Pliocene beds on sea beach near Wanganui (See page 311)
Looking down the valley from surface of Franz Josef glacier (See page 329)
The "Open Bible," a delta deposit near upper end of Lake Wakatipu
(See page 335) (Photos by Thomas)

PLATE LVI



Captain Altwell of the "Tahiti" (See page 339)
Deck billiards on the "Tahiti" (See page 349)
A race on deck (See page 349)

In places there are thousands of acres of burnt-off land. These desolate areas are expressive of man's waste of valuable timber and it seems a pity that these fine forests or at least the lumber they contain cannot be preserved.

At a big bend in the river we pass through the old town of Lyell built upon and surrounded by enormous gravel terraces which in the sixties were washed for gold. Lyell then boasted ten to fifteen thousand inhabitants. The whole region was sluiced thoroughly for its gold but only rotting dredges and tumbled shacks on abandoned claims remain to tell of the time when the region yielded the biggest gold nugget ever found in New Zealand and of the struggles of gold-crazed men in the pathless forest penetrated only by the raging Buller.

Placer mining has largely ceased but not until hundreds of thousands of ounces of gold had been recovered in this region alone. Today lode-mining is extensively carried on, and we had the good fortune to see something of the diggings at Reefton which is located on the Inangahua river some miles above its junction with the Buller. At this gold mining center the cyanide process is employed for recovery of the metal. The main mines are at Crushington where the quartz is pulverized. Some of the underground workings are miles in length and penetrate the mountain from one side to the other. There is plenty of available water for all purposes diverted from the numerous mountain streams. Hydroelectric plants furnish an abundance of cheap electric power. We were told that the production of gold to date in the Reefton area is upwards of £5,000,000.

Below Inangahua Junction the Buller valley again narrows into a remarkable gorge. We passed the famous Fern Arch and stopped to get a snapshot of Hawk's Crag which is a notch cut into the side of the rock wall of the valley in such a way that there is rock below, on one side of, and above the car; the unprotected side looks down hundreds of feet to the stream below. The forest is again very dense, and the bush contains in addition to the ordinary trees an abundance of tree ferns, "King" ferns, and many others. It is a wonderland for a botanist. For a hundred miles the vegetation is massed together along this drive exhibiting an endless variety which to our northern eyes is strange and novel. One longs for a tramp through the thickets, to the foot of some towering rimu and on to the slopes of the distant mountains whose dense forests appear and reappear in the clouds driven in from the sea. A railway line is being started up this valley; the first six or seven miles is one series of tunnels, bridges, and fills. It must be an expensive project, and we wondered how it can ever replace the motor lorries and busses now in operation. New Zealand railways, it should be remembered, are owned by the government and are not built as competing lines but to give service to the communities through which they pass.

THE MAIN TOWNS OF THE WEST COAST

Westport at the mouth of the Buller river is a thriving town of four thousand inhabitants. It has a good bar harbor and is the chief coal port of New Zealand. Nearly a million tons are exported annually to other parts of the Dominion and to other countries. The coal is bituminous and cokes well. The Mount Rochfort coal-field contains two seams, the upper is one to sixteen feet in thickness, and the lower is three to thirty feet thick. The Mokihinui field also has two seams; the larger, according to Park, maintains a thickness of sixteen to twenty feet over a considerable area. The estimated quantity of available coal in the Buller district is close to 150,000,000 tons. New Zealand has an abundance of coal, and it is well distributed throughout both islands. In kind it varies from semi-anthracite to lignite. The coal mines of the Dominion employ some 4000 men, and over one hundred mines are in operation. The coals of the Westport district rank among the best of the bituminous kind and are well known bunker coals.

Greymouth at the mouth of the Grey river is the chief port and largest town of Westland. It has a population of over 8,000, including the Grey valley boroughs. It is the center of the state-owned collieries which produce some half a million tons of coal annually. The river's mouth has been converted into a safe harbor by means of a large breakwater over one-half mile long, but the minimum depth over the bar is only twelve feet. The walls are built of local Tertiary limestone as attested by the echinoids and other fossils seen in the rock. The Grey river enters the ocean by way of a narrow but conspicuous watergap cut through a high ridge which is close to the shore and parallel to the coast. The gap makes the town very windy but serves as the only outlet for roads and railroads to the hinterland. The coast in the Greymouth region is open, and the waves attack it with great violence. Old beaches above the present one and some distance inland seem to suggest slow uplift. Between them in places are sand dunes which are more or less established. From the end of the breakwater looking southwest we caught our first glimpse of the great snowclad peaks of the Southern Alps. The Mt. Cook group, nearly one hundred miles away, stood out majestically as the early morning sun was reflected from their snowy sides and summits.

The coal-loading facilities at the docks both here and at Westport are well worthy of comment. Great steam cranes lift the loaded cars bodily off their trucks and swing them over the bunkers of waiting vessels where they are automatically dumped and then swung back into place, the whole process taking but a few moments.

In connection with these notes on the coals of this region, brief attention should be called to the extensive iron deposits of the Golden Bay district near Nelson. Here is located the largest and most valuable iron deposit in Australasia. Indeed it is said to be the largest on the vast Pacific seaboard in either hemisphere. That this great deposit of limonite ore, as yet practically untouched, should lie within a relatively short distance of the Westland coal mines is very significant in connection with the future manufacturing activities of the Dominion.

Hokitika is a small town of two thousand inhabitants near the mouth of a small stream of the same name. It has no harbor at present since the cost of keeping the river mouth free of shifting sand is prohibitive. Lumbering is the chief industry although agricultural and dairy products are sent away by rail. In the spring of the year (September to November) enormous numbers of whitebait, a small delectable food-fish, enter the river. Several canneries do a brisk business during seasons when the runs are good.

The town site is a low sandy tract barely above high tide. During great storms the place is often flooded. At the time of our stay the sea was relatively quiet, yet the thunder of the waves night and day on the unprotected shore was very disconcerting. Hokitika of today is but the ghost of its former self. In the gold rush of 1864 when the rich gold-bearing deposits of gravel were discovered, the region became the mecca of gold hunters. During the boom, Hokitika's population ran to tens of thousands; even Ross, ten miles away and now an obscure village of a few hundred people, had a population of over ten thousand. Little by little the available gravels were washed out, the population dwindled, and the shacks crumbled. Hundreds of acres formerly covered with magnificent forests were left strewn with unsightly heaps and ridges of worked-over gravels. Even the famous placer, Mount d'Oro, is desolate in the extreme. However, much of the gravel was too coarse for the equipment of the gold-seekers to handle, and they only scratched the surface. In addition, this great gravel bed of fluvial, fluvio-glacial, and marine origin is at least fifty feet thick back of Hokitika. Any opening made into it immediately fills with water since its surface is but a few feet above sea level a condition with which the pioneer gold digger could not cope. After several failures at handling this coarse, heterogeneous deposit it remained for the Rimu Gold Dredging Company to solve the problem. The company is a New York concern whose local manager, Mr. Cranston, received us most kindly and showed us the entire plant. The dredge is a floating dredge of the Brusies type and cuts a trench fifty-one feet deep to solid rock and two hundred feet wide. Forty feet of the gravel is under water. The floating part of the dredge is 116 feet long; the bucket line has 73 buckets, each carrying about ten cubic feet when full. Its capacity runs into hundreds of cubic yards per hour. The dredge is held in place by two struts which serve as anchors. When necessary to move forward, one strut is lifted and the outfit "walks" ahead. The stacker is 125 feet long. There are three decks for washing, and the mercury process is used for recovery. The gold is in the form of very tiny flakes, the occurence being known as beach lead. The dredge handles boulders up to two or three tons with ease. The 350 horse power used is hydroelectric and is developed at the Lake Kanieri power plant some ten miles away. Work goes on day and night and the recovery is "highly satisfactory". One eleven-day period netted 1105 ounces. The company owns twelve hundred acres, and at the rate of dredging for their first nine months it will take them thirty-five years to work out the claim. Mr. Cranston returned to America with us on the Tahiti. A new dredge with double the capacity of the first is in contemplation, and there are thousands upon thousands of acres of gravels untouched except for the surface washing alluded to above. Two hundred million dollars in gold is a conservative estimate of the region's yield since the sixties. Fully twice that amount, we were told, awaits the giant dredges backed by capital and operated by the skill and courage of men like Lewis, the Yankee dredge boss.

WESTLAND

The district of Westland lies between the Southern Alps and the ocean. It is one of the narrowest and longest geographical units of its kind anywhere. It is close to two hundred miles long and from fifteen to thirty miles wide. The habitable area is still narrower since the width just given is from the crest of the Alps to the sea. In places the flat lowland strip barely exceeds a width of five miles and ten or fifteen may be considered an average.

There is one good road lacking several bridges running close to half its length. When the torrential streams are fordable a government motor carrying mail makes semi-weekly trips from Hokitika down to a point below Fox Glacier. Beyond this the mail goes by pack horse. On the morning of July 30 we boarded this car for Waiho ninety miles away. The weather was frosty and clear and all wore heavy wraps, gloves and laprobes. A ton of mail and eight or ten passengers with their baggage gave the Studebaker a heavy load. In Westland temperature is measured by blankets. We heard our fellow passengers remark that it was "a blanket cooler today than yesterday", and that a certain part of Westland was "two blankets warmer" than another. In winter every New Zealander carries a large woolen blanket, a sort of glorified steamer rug, and he is "rugged up" when aboard the train, or in a coach, or even when seated in a hotel lobby. The hotel keeper expects his guest to have one and to add it to his bed if needed.

The road winds in and out past old placer dumps, over raging creeks, and occasionally over splendid bridges all of which are unusually long for such small streams due to the fact that these streams overflow widely after a rain but subside rapidly. Innocent looking gravel bars wholly dry may suddenly become the sites of raging torrents lasting an hour or two. Our driver pointed out where a car had been overturned and a man drowned at a place where he had crossed on dry ground a few hours before. It rains in Westland to the extent of more than one hundred inches annually. The more permanent streams are fed by the melting snows and glaciers of the high Alps. We passed many swamps and occasional lakes of great beauty. The village of Ross, mentioned before, is a place whose glory has departed. When gold failed to pay and men moved on there was left behind a mongrel population. Some of it is but the backwash of the great gold rush, but happily most of the people are a sturdy, vigorous, self-reliant and kindly folk who make the best of a difficult situation. An old one-armed man and a score of bent rheumatic and grizzly veterans of the sixties line up for the mail. It is their only diversion. They announce that Nick, the Irish wanderer, is back after a spree up the coast that cost him fifty pounds. To the near-by "pub" they go to devour the mail. A "pub" is a public house which dispenses liquor, and there are pubs and publicans a-plenty at every village and even at some cross-roads.

The settlers were scattered or gathered in groups on an area of flat land or about a saw mill. Lumbering on a large scale was going on at some points. We hoped it was being done scientifically for nothing so imperils this district as a wholesale deforestation that would permit unchecked erosion of the unprotected slopes. We passed by several areas of burned-over forest land.

Again and again as we glided through the forest we caught a glimpse of the snowy Alps or as we wound in and out among the placer dumps and abandoned sluices we caught a suggestion of the activities of this hundred-mile-long Gold Coast of New Zealand a half century ago. The tens of millions recovered helped make the Dominion but did little for Westland.

This rough broken strip of coastland is dotted with huge hills and ridges of extremely coarse gravel borne from the mountains. Some of the hills attain a height of several hundred feet, are steep-sided and close to the mountains; they take on a foothills character and are locally known as sugarloaf hills. Mt. Hercules is fully a thousand feet high. These irregularities as well as the more level tracts are softened by a covering of dense bush which as we proceed southward has as yet been little touched by the ax. Giant trees of rimu, kahikatea, and matai up to three or four feet in diameter stand straight and clean; ti, manuka, cracker bush and others form the lower shrubs while black ferns (*Lomaria*), king ferns (*Cynthia*), Prince of

Wales feather (*Todea*), and a host of other ferns crowd in beneath. Wild blackberry, gorse, and bracken overrun the clearings. Clumps of tree ferns arrest the attention at intervals. Masses of an epiphyte called *gigi* load down limbs and trunks with a besom of long aralia-like leaves. Lichens, liverworts, and mosses cling to tree trunks and moist slopes. Lycopods crowd every available space. It is winter, and hence there are no flowers except on a species of climbing rata; the only fruit is the "supple jack" whose rich red berry clusters hang quite out of reach. It must be glorious in the full green of early summer when the manuka is a blaze of white bloom. The swamps support a wealth of hydrophytes, among them a plant called *rapa* which resembles our American cat-tails. It must be remembered that this is an evergreen forest and that the netted-veined leaves remain green and on the trees throughout the winter.

South of Ferguson's on a strip of relatively flat land the road passes through the finest part of the forest. One hundred feet above the branches close overhead, and one passes for several miles under an arch of indescribable beauty. The light is subdued, and the driver who goes over the road every few days slows up the car. Everyone is silent. The underbrush and ferns are coated with a heavy white frost, the accumulation of many days untouched by the sun's winter rays which are unable to penetrate to the floor of the forest.

Fortunately this great forest is still crown land and may be saved from the ax and the fire. We sincerely hope that the people of New Zealand will preserve a part of this incomparable woodland of the great piedmont rainbelt. From the standpoint of its strange trees and the associated cryptogams, the perfectly developed straight and well-spaced trunks, sixty to eighty feet long, and its matchless beauty the forest should be preserved. For generations untold, men will come from all parts of the earth to visit this unique assemblage of trees whose strange features and primeval grandeur in their insular setting will appeal to their wonder and admiration, for there are no others like them on the face of the earth.

We had the pleasure of meeting in Westland Mr. Arnold Hansson of the Dominion Forest Service and to see something of his work in connection with the conservation and planting of the crown land forests. He was educated for forestry work first at Christiania, Norway, then later at the Yale School of Forestry. He is doing a great service especially in the reclamation work. We owe him for many fine photos of New Zealand trees and for several interesting reports on the work of the Forestry Department.

The isolation of Westland is a tremendous handicap. On one side is a well nigh impassable mountain range and on the other an inhospitable sea without a single safe harbor. From Arthur's Pass (3,038 ft.) at the north end to Haast Pass (1,800 ft.) at the extreme south end there is not a place to cross the mountains except by way of high and dangerous passes negotiable only by experienced alpinists. Cattle and produce must be sent to market by one or the other of these long routes or by rail from Hokitika. The telephone and the mail car have done much to relieve this extremely long and linear neighborhood, for neighbors they are. A woman runs out to post a letter and inquires about Mrs. Blank who lives thirty or forty miles up the road and sends a dozen eggs to another some twenty miles farther on. Floods which render roads impassable complete their isolation at times. At the larger settlements there are good schools and town halls for neighborhood gatherings. A public nurse looks after cases of illness while the nearest doctor is fifty to a hundred miles away. The people hope for a railway, and the line has been extended to Ross but the track between the latter place and Hokitika is little used. During the tourist season there is considerable motor travel when the roads and weather are favorable.

FRANZ JOSEF GLACIER

Our journey ended at Waiho where there is a commodious tourist hotel about four miles below the terminus of Franz Josef glacier. The approach through the bush is very attractive as now and again a glimpse is caught of the glacier face. A suspension foot bridge over the tumultuous Waiho river, turbid with fresh glacial debris, carries us across to another bush which covers a series of morainic hillocks directly in line with the glacier but still two miles or more away. The Tourist Path has been well selected with a view of bringing out effectively the setting of the glacier. At one point we catch a brief outline of the steep-walled valley in which its lower reaches lie, at another a survey of the lofty snowfields, and from a mound among the trees the whole setting seems framed and stereoscopic, while from a tiny placid pool the picture is reflected as from a mirror. A carpet of ferns heavy with hoar-frost lines the path. In addition to the large species noted in the Ferguson bush are small umbrella and kidney ferns and there is a wealth of lycopods, mosses, and epiphytes everywhere. A clump of tree ferns stands within a mile of the ice, and horses and sheep find excellent grazing within a stone's throw of the fresh terminal moraine. Abundant vegetation close to a glacier is contrary to the general opinion that glaciers occupy only cold and barren areas. Fifty-eight species of ferns, an azolla, and eight species of lycopods have been listed from the immediate vicinity of this glacier. Of the entire flora consisting of two hundred and eighty-eight species twenty-six of them, according to Cockayne, are alpine or semi-alpine in character—a remarkable condition in view of the low elevation.

The ice-front is steep and faces the north; in places it is vertical or overhanging and fully two hundred feet in height. The elevation of the lowest ice exposed is 692 feet above sea level. The glacier originates in a great snowfield or series of snowfields among which are Geikie, Davis, Salisbury, and Chamberlin Snowfields, ranging from seven to eight thousand feet in elevation. The glacier proper has a length of seven and one-half to eight miles. It thus has a fall of close to one thousand feet per mile. The snowfields are dotted with numerous nunataks and the precipitation in the snowfield area is in the neighborhood of about one hundred and twenty inches annually. From a great cave in the ice-front issues a swift stream, the head waters of the Waiho. The cave at the time of our visit was some thirty feet in height and extended back for about an equal distance. Considerable water trickled from its roof and the ice was quite leaky toward midday. In places there are great volumes of debris along the ice-front ranging from rock flour to boulders ten or fifteen feet in diameter. The pebbles and boulders are chiefly schists with a few pieces of slate and greenstone. All the pieces are flat, their shapes being due more to the structure of the rock than to wear by the ice. We looked in vain for glacially striated pebbles but scratches were common on the *roches moutonnées* at the foot of the ice cliff. The largest of these knobs, Sentinel Rock, towers quite to the top of the ice cliff. Strauchon Rock and Barron Rock are other prominent iceshorn domes while Park Rock and Harper Rock stand half buried in the ice front. Due to these prominent rock masses the ice-front has a more or less lobate aspect, but this character, the position of the subglacial cave, and other features are constantly shifting. The rate of flow of the ice is variously reported, Park gives sixteen feet per day, and Bell in the government geographical report cites a much smaller figure.

After a difficult climb up the northwest corner we reached the surface from which there is a magnificent view both up and down the valley. The rock walls of the valley show smoothing by ice for hundreds of feet above the present ice surface. The ice is highest in the center of the glacier whence the surface slopes gently down the sides which, however, are not in contact with the rock wall in the lower part of the glacier but end in a steep broken ice cliff. The surface ice was granular and much pitted but footing was not difficult except on the steeper slopes where sun cups helped materially. These are dish-shaped, concave depressions, six to twelve inches across and deepest beneath the lower edge.

There is very little surface moraine due to its having been swallowed up by the numerous crevasses. The latter in most cases extend longitudinally along the center of the ice but out near the margins they run more or less diagonally. The crevasses range from a few inches to two or three feet across, most of them being less than a foot. Since they extend mainly in a north and south direction, their width is affected to some extent by the sun's rays. In length they vary from a few feet up to hundreds of feet, and in depth they also vary. Some are full of quiet clear water, in others the water is in motion, others are dry. In a few of them water could be heard but not seen, and pebbles dropped into the larger dry ones rattled for several seconds before coming to rest. In places there are small well-like depressions eight or ten inches across and of unknown depth. Into one of these much surface water gathered and fell with considerable noise. Doubtless had our visit been made six months later the surface of the ice would have been much wetter. Dust wells were common and small pebbles were seen at bottoms of holes much too deep for the sun's oblique rays to penetrate.

At a distance, of about a mile above the terminus, the ice surface rises abruptly 150 to 200 feet. This results in a fine ice cascade in which the ice is fissured, cracked, and broken into such fantastic blocks and yawning crevasses that to ascend is well-nigh impossible. By use of the ice-axe a knife edge ridge among the seracs and pinnacles was finally scaled. From this vantage point there were several magnificent views, the finest of which was the impressive U-shaped valley seen in looking down the glacier. In order to get into position for a photo of this, it was necessary to turn about and in doing so the ice-ax slipped off into a thirty foot depression at the bottom of which was a narrow crevasse. Glock was out of sight exploring the east face for a place to descend to the ground, hoping thereby to ascend above the ice fall by climbing along the valley wall. The descent and recovery of the ax were accomplished but not without the greatest thrill of the whole trip. Glock gave up his attempt and we learned later that the best way to attain the surface above the lower ice fall was to go up a path along the valley wall without first ascending the frontal face.

At a point four miles above the terminus is the Great Ice-fall. Here the "ice falls over a thousand feet between colossal precipices on either side." Along this abrupt slope and at its foot the ice is riven into a forest of slender pinnacles, and the sight is said to be one of the most imposing in the Southern Alps. From this point to the lower ice-fall the surface is everywhere rough, uneven, and in places very steep.

Individually, Franz Josef glacier has several remarkable features. The low elevation of its terminus in latitude 43°26′ is unusual and may be accounted for by the heavy precipitation of the west coast, the steepness of the descent, the large contributing snowfields and the precipitous confining walls on either side. On the date of our visit the sun did not strike the lower ice before 9:30 A.M. and not all of it before 10:00 A.M. At 3:00 P.M. the ice was again in the shadow of the cliffs although the sun did not set for nearly two hours. This means that the total number of effective melting hours is greatly reduced at least during several months of the year. Again the region is one of considerable cloudiness as the high precipitation would suggest. Another unusual feature is the absence of surface moraines and glacier tables due, as pointed out above, to the highly broken character of the ice. The strong cascades, the multitudinous crevasses, and the scarcity of striated pebbles are other more or less individual characteristics. Generically the glacier conforms to the valley type with a strong terminal moraine, subglacial stream, and broad U-shaped valley.

Fox glacier, fifteen or twenty miles farther south, has many of the features of Franz Josef, and its terminus is fully twenty feet nearer sea level. However, the terminus of the eighteen-mile-long Tasman glacier on the other side of the Alps opposite Franz Josef is 2,354 feet above the sea, that of Mueller glacier is 2,550 feet and of Hooker glacier 2,882 feet. This difference of nearly 2000 feet in favor of the less sunny side of the mountains is to be explained by a lighter precipitation and by a much more gentle slope on the eastern side of the Alps.

Gallery Gorge near Waiho is an illustration of one of the scores of valleys of the region carved by wild mountain streams capable of being harnessed for the development of considerable power. Some very successful hydroelectric plants are being developed on a small scale. Near the footbridge over Gallery Gorge is a fine, hot, sulphurous spring where a bath house has been erected. This is one of the very few hot springs of South Island.

We cannot leave the glaciers of the Southern Alps without a few remarks about their extent during the Pleistocene or Ice Age. The present glaciers are but the feeble remnants of a tremendous ice sheet that covered nearly all of South Island and reached quite to the sea on both coasts. The bold peaks of the high Alps stood out as low nunataks above this ice sheet thousands of feet in thickness. Franz Josef, for example, extended several miles below its present terminus where it spread out and united with other valley glaciers into one common ice sheet of the piedmont type extending to the sea. In their wake they left an enormous amount of debris to be handled and sorted by fluvio-glacial streams giving rise to the extensive gold-bearing gravels so widely distributed on both coasts. Wherever the glaciers have disappeared from areas where they were vigorous eroding agents all the physiographic features made by strong glaciers in regions of high relief are developed on a scale rarely excelled in the world.

ARTHUR'S PASS AND THE OTIRA GORGE

Retracing our drive to Hokitika we left by rail for the Otira gorge. On the way we passed near Arahura river beyond which is one of the chief localities where the Maoris and later the

Europeans have obtained the famous pounamu or greenstone from which the Maoris fashion many of their highly prized and elaborately carved war clubs or meres and many articles of personal adornment. The trip up the Otira gorge and over the Pass is one of the sights of New Zealand, and it is made in a coach drawn by six horses "trained to a hair" to gallop around sharp curves and along steep precipices with ease. Cliff glaciers on the sides of towering snowclad mountains lie half hidden in the clouds; steep-sided, heavily forested valleys are far below; and awesome rockslides and tumbling waterfalls lend variety to the scenery. The Pass is 3,038 feet above the sea, but Mt. Rollaston and other eminences on either side are close to 2000 feet higher. The descent into the valleys of Bealey creek and Waimakariri river to Arthur's Pass station is fully as steep as the climb up the gorge but is less picturesque. The Otira railway tunnel through the mountain was opened soon following our visit. This tunnel is five and one-half miles long, and its completion overcomes one of the factors of Westland's isolation. The picturesque coaches, it is hoped, will continue to go over the Pass during the tourist season.

The eastern foothills are quite rough, and the region is given over to grazing. We saw flocks containing thousands of sheep and great herds of cattle. Canterbury plain between the foothills and the sea with its well-stocked and prosperous farms is a delightful change from the mountain topography.

CHRISTCHURCH AND DUNEDIN

At Christchurch we met Professor Nutting whom we had not seen since we left Auckland. He visited the splendid museums and college and these are described elsewhere by him.

Christchurch was founded as a model Church of England settlement and is more English than any other part of the Dominion. It is rapidly becoming a commercial and educational center, and due to cheap electric power considerable manufacturing is carried on. The site of the city is so flat that it is known as the "City of the Plains." One seldom sees so many bicycles and motors as travel its level streets.

In company with Professor Speight of the Museum we visited Banks Peninsula, a volcanic eminence between the city and the sea. This pile of rhyolites and agglomerates capped by flows of basalt makes a conspicuous eminence from the top of which the city looks like a flat checker-board, and out on the western horizon the snowy Alps stretch as far as the eye can see. Lyttelton, the port town, is seven miles distant from Christchurch and is built around an old sunken crater through one side of which there is access to the sea. From this place there is a tunnel one and one-half miles long on the way to Christchurch.

The distance from Christchurch to Dunedin is about two hundred miles, and there is very good express train service. A day's stop at Oamaru gave opportunity to see the famous shell beds at Target Gully and the hills of loess north of town. This loess, seen in a road cutting, is twenty-five feet thick and is as typical loess as that near Iowa City. Its origin is apparently similar, it being an eolian deposit blown from the dry glacial flats toward the sea during the closing stages of the Ice Age.

Dunedin is a prosperous substantial city settled largely by Scotch immigrants. It is picturesquely located on a group of hills at the head of a long inlet known as Otago Harbor. Its wharves, however, can be reached only at high tide by large vessels. Here are the main offices of the Union Steamship Company, and there are numerous thriving factories. The railways of the Otago district center here, and the port is the outlet of a rich farming and grazing district as well as of coal and gold ore. Dunedin is the site of University College and has schools of Medicine and Dentistry. There is a fine museum and a well known School of Mines of which Professor James Park is the director.

LAKE WAKATIPU AND THE REMARKABLES

From Dunedin we made a rapid side trip up into western Otago to see famous Lake Wakatipu nestling at the foot of the Remarkables and other bold mountain ranges which deploy out of the Southern Alps. The railway passes through a prosperous country and through many attractive and busy towns and villages. Balclutha, latitude 46°17′, was approximately the southernmost point we touched. As we approached the drier foothills we saw considerable evidence of damage to agriculture by rabbits. Systematic "rabbiting" has kept this pest pretty well in check over all New Zealand, but it was a revelation to see wagon-loads of rabbit skins going to market and scores of pelts drying on fences and bushes about the country homes.

The plains of Otago are a series of long slopes which end abruptly against subdued escarpments. They are worn down fault blocks as described on a previous page.

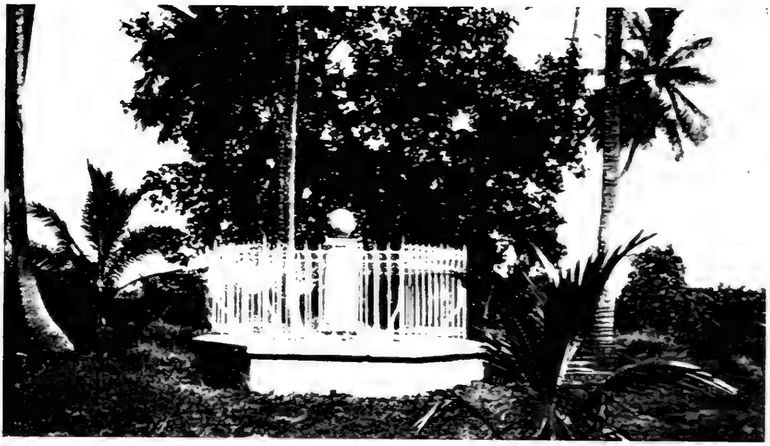
Kingston is the railway terminus and is at the south end of Lake Wakatipu. This lake is in a deep ice-gouged valley fully fifty miles long, S-shaped, and 1200 feet deep. At Kingston a strong moraine dams the valley, and the lake has found an outlet near its mid-length at Queenstown by way of Kawarau Falls into a river system other than that to which its drainage area originally belonged. Beyond Kingston travel is entirely by boat, and the journey from this point to Queenstown by moonlight with the rising moon dodging in and out among the peaks of the ice-covered mountains was a sight of rare beauty and charm.

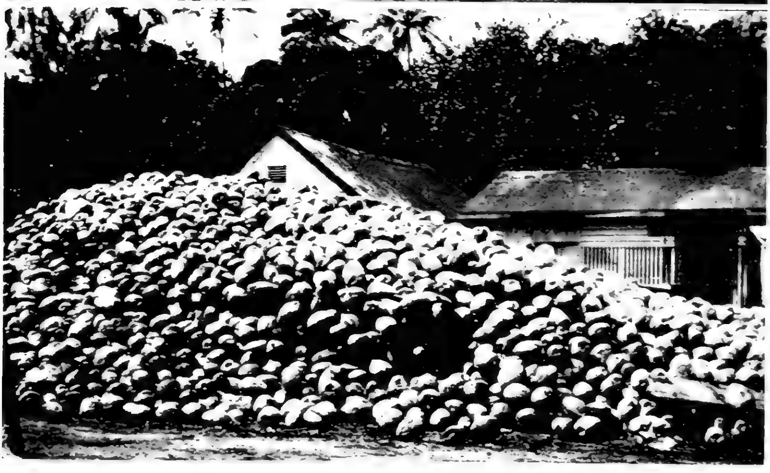
The Remarkables are all that the name suggests. The crest of the range is well over 7000 feet high and only three or four miles from the lake whose surface is but a little more than a thousand feet above the sea. Obviously the slope from the lake shore to the crest is decidedly steep. The summit of the Remarkables towered above the thick ice of the Pleistocene while their sides for thousands of feet above the lake were smoothed and worn by ice action. This makes their tops appear very rough and saw-toothed by contrast, and when covered with snow and ice they are a beautiful sight. The Richardson, Eyre, and Humboldt ranges enclose other sides and segments of the lake. All these mountains have been glaciated, and they record the results of ice sculpturing on a grand scale. Glock remained at Queenstown and climbed the high eminences in the vicinity of Ben Lomond and Bowen Peak gaining a glorious panorama of the Remarkables and adjoining mountains. The writer proceeded up to the end of the lake to see Dart valley which leads up to Paradise and to Mt. Earnslaw (9165 ft.) on which is a good sized glacier. The Dart river has built an extensive delta which encroaches upon the upper end of the lake for some miles above Kinloch and Glenorchy. A strong stream rising in the Richardson mountains near the north end of the lake built an enormous delta into glacial lake Wakatipu when its surface due to ice dams and other obstructions was much higher than it is today. When the lake level subsided the Glenorchy delta was left above the level of the present lake. Valleys subsequently cut through the delta reveal its structure unusually well. Locally this dissected delta is called the "Open Bible."

A few words of acknowledgment are due our many New Zealand friends who helped the geologists in countless ways. To Professor P. G. Morgan, director of the Geological Survey we owe much for his generosity in furnishing indispensable maps and a nearly complete set of the Survey Bulletins. His associates, Messrs. Marwick, Ferar, Henderson, and others, aided us greatly with advice concerning localities to be visited, routes to be followed and other points so valuable to strangers in a new region.

Professor Bartrum accompanied us to places of interest about Auckland and presented us with several valuable papers and specimens. Professor Speight guided us over the Banks Peninsula with which he is so familiar. Professor Park took us in hand at Dunedin and gave us much of his valuable time. We shall not soon forget an evening with him discussing the broader aspects of the geology of Australasia. Several fine specimens, among them some bones of the moa, were given us from his own collections. Dr. C. A. Cotton of Wellington piloted us over the region surrounding the Port Nicholson depression. We were much impressed with his mastery of the geomorphology of the area, and we owe much to him for many kindnesses shown us when at Wellington. The Hon. Mr. Thomson of the Legislative Assembly gave us considerable valuable information drawn from his wide knowledge of the natural history of both islands. He presented a set of papers by his son, Dr. J. Allan Thomson, who, we regret, was quite ill at the time. These gentlemen and many others whom space forbids mentioning by name have our most grateful acknowledgments of their assistance.

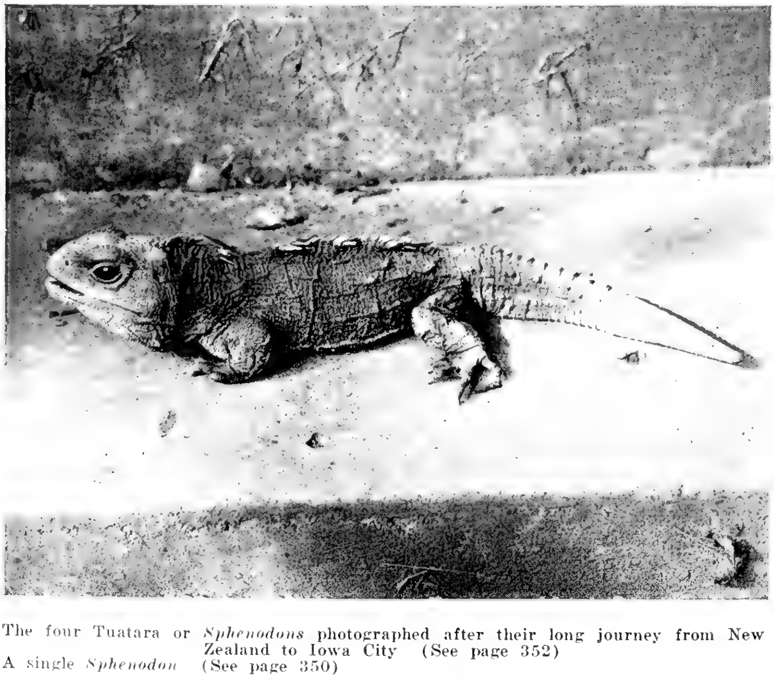
We look back upon New Zealand with keen pleasure and harbor a hope that some day we may again see her glaciers and geysers, her cold lakes and hot springs, her mountains and plains and best of all her sturdy, hospitable and broadminded people.





The Cook monument on Tahiti (See page 343)
Harbor of Papeete, Tahiti (See page 345)
A pile of coconuts at Rarotonga These furnish the copra of commerce, the main export from this island (See page 341)

PLATE LVIII



The four Tuatara or *Sphenodons* photographed after their long journey from New Zealand to Iowa City (See page 352)

A single *Sphenodon* (See page 350)

CHAPTER XIX

HOMEWARD BOUND OVER A LONELY OCEAN

August 15 was sailing day and of course a busy one for all of us. Bills had to be paid and the innumerable "last things" attended to. I went early to see Stoner and found him better but still very weak. It was fortunate that Mrs. Stoner with the training of a professional nurse was with us to look after him. I was very anxious to get him safely aboard the Tahiti as it would have been hard to leave one of our little party behind and on the sick list.

It rained during the morning, but in showers, not a continuous down-pour. We put all our collections, including the cage with the four tuatara, or sphenodons, that were to travel in my charge, on a government lorry and took them to the dock. The police stopped us at the entrance to the wharf and were inclined to make trouble about the sphenodons but were finally convinced after some argument that these animals were important passengers consigned to the State University of Iowa by the Dominion Government which had also given me a formal permit duly signed, sealed and delivered to export them from New Zealand.

I then hunted up the ship's butcher in whose charge they were to be placed in accordance with instructions from the steamship company. He was asleep and not very amiable at first, but finally undertook the responsibility for a consideration. When we took the cage containing the lizard-like creatures to the butcher's quarters some of the crew objected. "I say, Mister, we don't eat those things!"

I went back to the hotel for lunch and sent a cable to President Jessup: "Starting home, well, successful," which I knew would be welcome news to our friends at home; then I took a taxi and transported my baggage down to the wharf.

There seemed to be no system about getting luggage aboard as the stewards, it appears, do not handle it except on the ship; but I finally induced one of them to take my things up the gangway and to the stateroom which I was to share with my old "bunkie" Wylie. Then I took a place at the rail and watched our collections and equipment hoisted aboard and lowered into the hold, Stoner who usually attended to such matters and Thomas, who was supposed to be transportation agent, not yet having put in an appearance. I checked off the fifteen boxes and tanks and the big packing case containing gifts from the Dominion Museum to the State University of Iowa and found them all accounted for according to our list. As they were to be transported as baggage, by an agreement with the Union Line, no invoice was made out, and this made trouble for us later on.

Finally, to my immense relief, I saw Dr. and Mrs. Stoner come up the gang plank, although the poor fellow looked quite weak and pale.

Mr. and Mrs. Hislop and several other friends came to see us off. He is the "man who does things" here and proved an invaluable friend to us. His was the last face I could distinguish as we slowly steamed away from the dock, his hat waving above the crowd, a last good-bye from our best New Zealand friend.

On going below, however, I found a farewell letter from him, also a letter from my wife written June 16, two months before.

As on all previous expeditions of which I have been in charge, the moment of sailing for home, with all the party safely on board and the collections stored away in the hold, was one of the happiest of all my experiences. No matter how smoothly things go or how little there has been to worry about, the responsibility of being the leader of a party in foreign lands is greater than would be imagined by any one who has not had that particular experience. Each time I have had the feeling that there must be an end to the extraordinary run of good luck which had attended former undertakings of this sort, and that it could not forever be my good fortune to report "All well. Expedition successful" at the beginning of the homeward bound voyage.

Wylie and I had a very comfortable deck cabin for which each of us would normally pay $20.00 extra, and the others were equally well accommodated. Across our tickets was printed in red ink "No extra charge is to be made for this cabin. Orders Headquarters." We believe that we owe this courtesy to Mr. Irons, General Agent for the Canadian Australasian Line at Vancouver. Each berth had an electric light like those on our Pullman cars, and a number of other welcome conveniences.

The morning after sailing we enjoyed smooth water and bright sunny weather. There was a very large and open upper deck where we could bask in the sunshine or engage in deck sports. Stoner appeared at the table but seemed to have little appetite. All the others of our party were well and happy. Wylie welcomed the long rest of the homeward voyage. He surprised me the other day by presenting me with a very handsome Fiji war-club. He knew that I wanted one, but as I did not go into the interior of Vitilevu, I had no opportunity of securing one as the others had, and I was secretly quite envious. Wylie secured the one he gave me, at Wellington, from the estate of the famous Bullar family, in whose possession it had been for several generations; it was undoubtedly genuine and not made for the tourist trade.

The Tahiti was a great deal smaller than the Niagara but more comfortable and ''homey.'' It was not at all crowded and had a comfortable lounge and smoking room besides a reading room with an electric stove which was not needed after the first few days. We were quite prepared to appreciate warm weather again after the chill of New Zealand.

The four sphenodons were quite contented in their cage on the lower deck in charge of the butcher, who said he would get them through in good shape if possible. He had had considerable experience in caring for animals on long voyages, and remarked that he once had a couple of lions on a trip. The animals seemed more lively in their new surroundings than I had seen them before. They were to have their water tank filled with fresh water every day and to have fresh beef twice a week.

Mr. and Mrs. Welch, our companions on the Niagara and the trip to Bau in Fiji, sat at our table. They had been to Australia since we had seen them last and seemed glad to be with Americans again.

We lost a Sunday on our voyage to Fiji, but we made up for it by having two Wednesdays on our return voyage on the Tahiti. Wednesday No. 2, came on August 16. We were sleeping well and all were having a most welcome rest. It was rapidly getting warmer as we went north toward tropical seas. We met our skipper Captain Altwell, who said that he had had instructions to take care of our party and would do all in his power to make us comfortable. The sphenodons were doing finely and seemed to be brighter colored, perhaps owing to more ample bathing facilities. That day was the longest in my life, for we passed forty-eight hours under one date on account of traversing the 180th degree of longitude, eastward bound.

August 17 was another bright day but with more sea running and a chilly wind from the south. Our first stop was to be at Rarotonga, eighteen hundred miles out from Wellington. This is one of the longest voyages taken by any regular passenger steamer in the world without putting in anywhere for fuel or provisions, the entire trip being 6,090 miles, traversing nearly 60° of longitude and 80° of latitude, more than a third of the distance around the globe. The ship's doctor saw Stoner that morning and diagnosed his case as a not very severe attack of jaundice.

Those were indeed lonely seas, a few gulls and petrels being the only birds seen. We were getting acquainted with our fellow passengers and Thomas, the best mixer in our party, went in for various deck sports and met more people, and enjoyed them more than any of the others.

We received daily marconigrams and were in touch with the world all the way across. That day they indicated a better prospect for settling the coal strike in the United States, but little favorable news regarding the great railroad strike about which much disquieting comment appeared in the New Zealand papers.

August 18 the ship was settling down to the routine of a long voyage and life was mainly a matter of eating, sleeping, smoking and talking. Awnings stretched over the upper deck one morning, indicated that we were approaching the tropics.

Stoner had been ordered to keep to his berth for a few days, much to his disgust. The doctor intimated that he feared complications and a possible operation which he very much dreaded with the facilities at his disposal on the Tahiti.

On August 19 I read up on Rarotonga and Tahiti beforehand so as to save time while in port at these places and on the morning of the 20th we were anchored off Avaruna, the capital of the Cook Island group, situated on Rarotonga, the largest and most important of the islands, with a circumference of about twenty miles. It is quite mountainous and the early morning view from our anchorage was exquisitely beautiful; the town nestled down between the mountains and the sea; there was the usual fringe of palms, and, beyond, the rugged mountain peaks, some of which were three thousand feet high. They were tinted with red from the rising sun and thrown into sharp relief against the purple and blue of the lower slopes. Two wrecked hulks were going to pieces on the shore, one a steamer, the other a sailing ship.

There were no formalities about going ashore, and we were towed in rowboats by a small tug.

Mr. and Mrs. Welch, Mrs. Stoner and I took a delightful twenty-mile auto drive around the Island. The road lay along the shore for the most part, in the dense shade of palms and other tropical trees. We noticed between the road and the sea-beach numerous graves made of cement with tops like the sloping roofs of houses, and with a small shed roofed with corrugated iron over each. It looked as though every family had its private cemetery in its yard, and the effect was rather gruesome.

The native houses were much like those of tropical islands everywhere, light frames, wattled walls and thatched roofs; but were often quite picturesque and comfortable looking. The whites had better houses, usually of wood and with wide cool verandas. It was Sunday and we passed several churches, usually of the Congregational faith, and groups of people dressed in their Sunday best. The children were quite pretty, often beautiful, and the young men and women often strikingly handsome; but they seemed given to too much avoirdupois in middle age, and beyond that they quickly became aged and lost all their good looks.

Returning to the town we looked in on some of the curio stores, which are open on steamer day even if it is Sunday, where there are all sorts of fancy mats, hats, fans, shell work, picture post-cards etc., to tempt the traveler. I took a number of photographs myself during the ride and about the town and among other things I "shot" a large pile of coconuts whose meats furnish the "copra" of commerce used mainly for the extraction of oil, and form the principle article of export from those Islands. The Cook Island group is now a dependency of New Zealand and Sir Maui Pomare, of Wellington, is the official administrator. He is a Maori gentleman and tradition says that Rarontonga is one of the Islands from which his ancestors came; and so by a strange turn of fate a descendant of one of these refuges from Rarontonga now rules that island which has become a dependency of the new world discovered by the wanderers of something like six centuries ago.

After writing some letters to New Zealand friends and putting them in the mail we returned to the Tahiti which already seemed like home.

August 21 brought pleasant weather with nothing to vary the monotony of the daily routine on ship-board, as follows: 7:00 A.M. "Bawth, Sir;" 7:15, "Tea, Sir;" 8:00, walk a mile on deck, usually with Wylie; 8:30, breakfast; 9:00, read or write in smoking room; 10:00 to 12:00, sit and chat on upper deck; 1:00, lunch; 2:00 to 3:00, take a nap; 3:00 to 4:00, write up notes; 4:00 to 6:00, recreation on deck; 6:30, dinner, for which a good many passengers "dress;" 7:00, coffee and cigars in smoking room often with the Welches; 8:00 to 9:30, social hour; 10:00 P.M., turn in below for a sound sleep until "Bawth, Sir" the next morning. I met a number of pleasant people but none to whom I was so drawn as to some on the Niagara, going out. In the evening we were invited to a concert given by second class passengers, on the forward deck.

The next day, August 22, was decidedly warmer and the officials and stewards all appeared in white uniforms again; that meant tropical weather.

Just before noon a third class cabin woman of ample proportions and a huge yellow jacket (she had been known as "Quarantine") was taken with her four or five children to the "brig" or ship's hospital on the after deck. One of the children had developed a case of mumps, and without avail she used much language in protesting against this outrage.

At lunch time we were approaching Moorea, one of the Tahiti group, its huge mountains looming up on the horizon. At two o'clock we were coasting along the shore of Tahiti which looks a good deal like Dominica, one of the British West Indies, its lofty mountains hiding their heads in the lowering clouds.

Papeete, the capital city was reached about two-thirty. It is a very picturesque town with many fine shade-trees along its streets and quaint French-looking houses peeping from between them. There were numerous pretty white schooners almost poking their bows into the trees.

There was no formality at all about going ashore, not even a medical inspection or a call for passports. The ship tied up at the wharf and we simply walked down the gangway without being requested to secure a "gangway pass." We took a stroll along the water front where it was cool and shady and found the town very different from others we had seen in the South

Seas. Of course this might have been expected as Tahiti is a French possession and Papeete is one of the oldest settlements in the South Pacific. The houses were mostly wooden and typically French in architecture with "French blinds" and a good deal of filigree work about them; many of them being embowered in tropical trees and flowering plants. Back of the street along the water front are others parallel to it, all of them very well shaded and giving the impression of somnolent coolness.

The people are much like those of Rarotonga, but with a considerable admixture of Chinese and European blood. Some of the native men are strikingly handsome and the children are often beautiful. Occasionally one sees a really pretty woman. Not so many of them were given to over-weight as those we met at Rarotonga. The people have the *dolce far niente* air that reminds one of southern Italy.

We returned to the steamer about six o'clock in the evening just in time to see an exquisite sunset over the placid harbor and the peaks of Moorea beyond. It was a scene comparable with a gorgeous sunrise we saw off the island of St. Vincent in the West Indies four years before; a picture never to be forgotten. In the evening some of us went ashore to engage in the metropolitan whirl of night-life in Papeete but found it not so very exciting after all. We were interested in noting that the American ice cream cone had made its appearance in this far away island.

The law requires the steamers of the Union Line to remain at Papeete at least twenty-four hours, so we had almost all of the next day, August 23, for adventures ashore on this island, perhaps the most beautiful in the vast expanse of the South Pacific. Certainly it is the most written about and is pictured more frequently than any of the others. And indeed it deserves its reputation as nothing that I have seen could surpass its loveliness of high purple mountains, deep gorges, wealth of vegetation and encircling coral reefs beyond which roared the breakers; and still further out the deep calm of the blue sea. Mr. and Mrs. Welch and I hired an auto for an around-the-island ride which afforded many entrancing vistas.

We saw Cook's Monument marking the spot where that great navigator took observations of the transit of Venus in 1769. This illustrates the influence of the stars on terrestrial affairs, for it was at the instance of the Royal Astronomical Society that

Cook made his famous voyage, the immediate object being observations on the transit of Venus. Incidentally he fixed the names of many groups of islands in the South Pacific, Cook Island, which we visited but a few days ago, the Society Islands, one of which is Tahiti, named in honor of the Royal Society under whose auspices Cook sailed, and a number of others.

On this ride I met with the only serious personal loss of the entire trip. Of course I had my camera along and took a number of photographs and in some way dropped my book containing notes and records of exposures and other photographic matter. I imagine it occurred while I was walking about in the brush trying to get a good picture of Venus Point lighthouse; at any rate I never saw it again, although I left notice of reward to the finder. Fortunately my negatives were all serially numbered and most of the subjects noted in my daily journal so that I was able afterwards to recognize and properly designate all of the photographs.

That evening while the Tahiti was still tied up to the dock, I noticed a Chinese man and boy paddling a small canoe along the side of the ship picking up stray bits of bread thrown from the cook's galley. These were deftly skimmed from the surface on a paddle blade and put in the shallow basket in the bow of the canoe. I suppose no people in the world are more scrupulous about salvaging every particle of food than are the Chinese, which doubtless accounts for their thrift the world over.

At Papeete we were joined by a motion picture outfit that had been making a film at Tahiti, utilizing the magnificent scenery of that tropical wonderland to make a blood-and-thunder picture of the South Seas. Some of the outfit came aboard more than "half-seas over" and proceeded to make a "rough-house" of our peaceful vessel much to the disquiet of the Americans of our party, as it was an American company of course. One big brute of a fellow who was doubtless the heavy villain of the story, made himself particularly obnoxious, roaring like a mad bull at the stewards and using a vocabulary that I have seldom heard surpassed in profanity and indecency. I believe the company included some thirty people all told, and the prospect of being shipmates with them for two weeks was not alluring.

The Society Islands, the main one of which is Tahiti in S. Lat. 18°, W. Long. 160°, were discovered by Captain Cook in 1769 and have a population of eleven thousand, about one-tenth of which is European, mostly French. Papeete, the capital, has a population of three thousand six hundred. The main products are oranges, copra, pearls, vanilla, *beche-de-mer* (big holothurians) cotton, fungus and phosphate, according to my notes taken from "Stewart's Handbook of the Pacific." Cook said that "the natives surpass all others in physical beauty." The islands have been described by many writers from Captain Cook down to Frederick O'Brien and pictured by many artists.

Impressions of Tahiti from the ship's deck: Pretty white schooners against the dark green of the trees and deep shadows of the water front. Bad smells from the huge piles of copra stored in the wharf ware-houses. French idlers along the water front with long pallid faces. Chinaman with his family in a two-wheeled cart. Native men with magnificent physiques, more alert looking than at Rarotonga. The women also beautiful, with lustrous eyes and skin almost of our University color "old gold." All degrees of racial admixtures, but the people generally a light brownish yellow or golden tan. Pretty houses embowered in flowers and over-shadowed by palms of various sorts. A water cart laying the dust and cooling the streets along the water front.

While ashore we visited the cemetery of neat graves, ornaments of fancy bead-work wreaths, crosses and hemispheres of glass enclosing flowers often reduced to dust. There was but one American buried there, so far as we saw, a sailor from a United States vessel. It was very hot in the sun but the streets were cool and quiet everywhere. We saw a number of white babies with Tahitian nurses, often quite neat and attractive looking women.

Looking back towards the wharf we could see the S. S. Tahiti, our floating home, standing out clear in the sunshine, the fantastic peaks of Moorea purple in the distance across the intense blue of the ocean. Further inland we saw very populous Chinese houses with prosperous looking truck gardens. Native homes were thatched with palms and walled with reeds. People everywhere greeted us courteously. The Island of Oahu may be as pretty as Tahiti, but it has been too much modernized by the American hotels and various enterprises to retain its original charm; there is much more bustle and feverish movement than at Tahiti, where the ever-lasting calm of the real sleepy tropical island is unspoiled as yet by the turbulent world.

On the dock there was a dense crowd to see the motion picture people off. Chinese women in black silk trousers and sack-like coats were carrying little babies, and the motion picture camera was "shooting" the crowd and embarking company. There were many good-byes and some tears, for these invaders from America had spent several months and much money in Tahiti.

We sailed out of the lovely harbor of Papeete at five P.M. to begin the last and longest leg of our voyage, three thousand six hundred miles to San Francisco.

August 25 we slept well with a cool breeze in our stateroom. I had been anxious about the tuataras fearing their sudden introduction into the tropical heat from the winter cold of New Zealand, but they all seemed all right and they appeared to enjoy the voyage in an undemonstrative way, particularly appreciating the frequent douches of cold water administered by the butcher who was determined to do his duty by them.

Stoner was not allowed to go ashore at Tahiti, but saw what he could from the ship's deck and visited the island vicariously through his wife who saw a great deal and got a number of photographs and other mementos.

August 25 was the first rainy day of the voyage which was then just half over. There were two men on board bound for the Mayo Clinic at Rochester, Minn. The nurse finding that I had been there, asked me to do what I could to cheer them up a bit.

Our wireless received reports from the world every day and we found a copy of the mimeographed miniature newspaper at our place each morning at breakfast. The news of a great railroad strike was disquieting.

As we neared the Equator there were more living things to be seen at sea. Small schools of flying fish rose from the ship's bows every now and then, pursued their dipping flight for a hundred yards or so and plunged back into the blue. A shark and some dolphins were seen. We crossed the line again about 8:15 in the morning of August 27 and felt that being again in our proper northern hemisphere we were nearing home; we greeted the North Star as an old and valued friend. Stoner and the tuataras were doing well. The latter were probably the most distinguished passengers on board the Tahiti. Many people asked permission to visit them in their quarters on the lower deck near the butcher's stateroom. They were more lively as the weather grew warmer and really seemed to enjoy their frequent baths.

Deck sports were on nearly all day. A good many passengers indulged in them even on Sunday. Services were conducted in the lounge, a missionary being in charge. The singing was very good as these Colonials are apt to know more about vocal music than we Americans do. There was a good deal of drinking in the smoking room; I noticed two of the motion picture young women drinking a good many cocktails during the course of the day and particularly in the evening. The camera man of the company played the flute very effectively at the Sunday evening service, and was quite an artist with the pencil. He said they exposed ninety thousand feet of film in making their Tahiti picture but only seven thousand feet appeared in the completed production, which I afterwards saw at Iowa City; it was regarded as a very beautiful picture so far as the scenic effect was concerned. Another man, the star of the company, we all admired greatly.

We had not passed a single ship at sea since leaving Wellington but were daily exchanging wireless messages with several of them.

A ministerial looking, tall, well built man with a high, gray pompadour and intellectual face and head turned out to be a Pinkerton detective bringing home a man charged with absconding with the funds of a bank in Honolulu. The prisoner was a young fellow, quiet and continually reading in the smoking room. For a while I suspected that he was a theological student or returning missionary. He made the fatal mistake of supposing that he could lose himself in an out of the way place and fled to the interior of Tahiti. A moment's consideration would have shown him that a stranger is marked by every one in such places and all the natives knew just where he could be found. So the detectives had no trouble whatever in locating their man. He sat between two of them at the table not far from us and if he got up was at once followed by one or the other of them.

On August 29 we were in the doldrums or belt of calms, but struck the northeast trades late in the afternoon. I was much interested in what the camera man of the motion picture outfit told me of the complexity of combining several different scenes to make one picture. For instance, the director wanted a certain type of house with certain shrubbery plants in the fore ground and palms behind it with mountains rising beyond, also a moon and drifting clouds. He made separate pictures for the house, shrubbery, palms, mountains, clouds and moon. These were afterwards superimposed so as to make a picture that satisfied the demands of the director.

The man who was brought on board on a stretcher at Papeete was a general favorite, called "Pat." He was said to have had more hairbreath escapes than any one else on the ship. He had been shipwrecked three times, in one of which his entire family was lost; had fallen five hundred feet from an aeroplane besides having numerous other thrilling adventures. He was a quiet, unassuming sort of fellow.

One day all passengers were required to make declarations for the United States customs, so it looked as if we were nearing port. Another sign of nearing home was the reappearance of the Great Bear above the northern horizon.

There was considerable gaiety on board in the evenings, including dancing on deck, some of the womens' costumes being apparently quite up to, or down to, the reputation of the much advertised Hollywood crowd. But among them was a dear little girl about ten years old, called "Mary Jane." She was perfectly naïve and unspoiled and had most charming manners. We were told that she was paid an enormous salary but her mother, who accompanied her, was evidently a woman of sound principles and good sense and had succeeded in keeping her artless and unspoiled in spite of unfavorable surroundings.

On August 31 we entered the North temperate zone. The long climb from the bottom of the "track chart" posted near the dining saloon added a step in our progress for each day. Commencing down near 41° South Latitude we had traversed a good deal of the south temperate zone, the south and north tropical zones and were reaching our destination in the north temperate. On all this long voyage there had been nothing like a storm or even really rough seas. There had been occasional showers, but not a day without sunshine. It had been comfortable every day in our staterooms without using the electric fans. We had traveled over twelve thousand miles at sea since leaving Vancouver and, except in the vicinity of ports, had seen but two vessels during the whole time and these were companion ships going in the opposite direction, one on the outward voyage and one while homeward bound. We had seen few birds, few fishes excepting flying fish and practically no phosphorescence.

Friday September 1 was considerably cooler and I was still feeling anxious on account of lack of news from home. One of the nurses summoned me to see a sick man in the second cabin who was on his way to Mayo clinic as a last hope, after many years of intense suffering. His case was pronounced hopeless by his physicians at home. He was a fine manly fellow, able to be about but with years of frightful suffering behind him. I hope I was able to cheer him up a bit, as courage is one's best asset.

Stoner and the four tuataras were all doing well. In the deck sports there was an exciting tug of war between selected teams from the British and American passengers, the Americans winning both times. Wylie, who was a heavy-weight athlete in his college days and still a formidable man where weight counts, won considerable glory in this event. Glock was one of the championship couple in the deck quoits tournament. These deck sports are a prominent feature on all British ships and do much to vary the monotony of long voyages and serve also to keep the passengers in good physical condition.

The next morning, September 2, I was seated at the breakfast table when a steward brought me a marconigram from my daughter at Detroit, Michigan, saying that all was well at home. It was interesting to note that the message was received several hours before it was sent, which of course was due to the difference in longitude of the sending and receiving stations.

The sea became rather "lumpy" as we neared the American coast. There was much drinking on board as the passengers were taking advantage of their last chance before reaching prohibition territory. There seemed to be little effort to restrain them and they kept up a veritable "rough house" nearly all night with a good deal of profane and even indecent language.

September 3 was our last Sunday at sea. The services were poorly attended as a number of passengers were suffering from the "morning after" effects. We packed our trunks for the last time before reaching home as we were but two hundred miles from San Francisco.

Dr. Stoner was a good deal better. The poor fellow had not been off the ship since leaving Wellington and missed landing at both Rarotonga and Tahiti, but the sea voyage with its rest and medical attention had doubtless been a good thing for him.

September 4 was a busy day. We took on our pilot at 3:15 A.M., and were up shortly after five in the morning to find the ship anchored at quarantine and the engines at last at rest. The medical inspection took place in the chilly dawn and consisted chiefly in our passing in review before the Inspector as our names were called. Passports were not even looked at. We had breakfast on board and were allowed to land at about 7:30, the ship then being tied up at her dock.

The tuataras had stood the voyage well and the butcher had earned his tip. When my strange pets were taken to the customs house they were the object of excited attention but were passed without trouble by the customs officials. My personal baggage was opened but not disturbed,

Thomas was introduced to the chief official and acted as our transportation agent in getting collections and equipment through.

Our party separated at the customs house, Wylie and I being the only ones who intended going right through to Iowa City as quickly as possible. My chief duty was to get the four tuataras through as quickly and safely as practicable; no mean responsibility. As it was Labor Day we expected trouble in getting off that evening, but the railway officials put through our change of routing very quickly and had arranged for our Pullman accommodations on the night train.

After passing customs Wylie and I took a taxi to the ferry wharf and wired our safe arrival to President Jessup and our families.

I had a great time arranging for the transportation overland of our distinguished companions, the tuataras. It was exceedingly important that I be on the same train with them throughout the trip so as to be able to attend to their wants in the way of food and water at proper intervals. It was therefore necessary to have them sent as baggage if possible; but the baggage man promptly vowed that it couldn't be done, never having been done (which was strictly true) and that it was therefore unthinkable. I demanded an interview with the baggage master himself and he, being a man of wisdom and resource, looked the strange creatures over and said, "Those are mud puppies. Puppies are dogs. Dogs are domestic pets. We will send them through as baggage billed as domestic pets!" The really great mind can always find a solution for even the most perplexing situations and so by paying a fee of \$6.50 we secured a baggage check for the tuataras as "domestic pets." Probably this was this first time in history that these strange "living fossils" of the Antipodes were ever called by that name.

All of our business having been attended to, we took a ride in a "rubber-neck" auto to Golden Gate Park and around by the Presidio. Things have changed since I was there nearly twenty years ago and the region of the Cliff House looked a good deal like Coney Island. After a light supper at the Ferry building we took the boat to Oakland and our train. After arriving there I inspected the precious tuataras in the baggage car and interviewed the baggage man who was to have them in charge, the interview including a very reasonable tip. He promised to care for them and to bespeak the good offices of the man at Ogden who would see them still further on their way. And so we started on the last leg of our long journey in excellent spirits and with no thought of future trouble; but the next day brought new anxieties regarding our fellow travelers, the tuataras.

After a comfortable night's rest and breakfast, I went a little before noon to inspect my pets in the baggage car, taking along some fresh beef procured from the dining car steward. Imagine my dismay when I found that the baggage car had been set out from the train somewhere back in the Nevada desert on account of a defect probably due to the activities of the shopmen, who were then conducting their famous strike of September 1922! No one could give me any information as to when that baggage car or its contents would be sent on. I was told, however, that the baggage man I had interviewed at Oakland remained with his car until it reached Ogden and so I had to content myself with trusting to him and to Providence to see the tuataras safely through. I also wrote full instructions to the baggage master at Ogden, impressing him with the unique value of the specimens.

We reached Omaha about 6 A.M. on September 7, where I left another letter with the baggage master about the tuataras and just caught our train for Iowa City. At Des Moines we stopped for about two hours and called on the Des Moines Register to report our safe return. It was certainly a "grand and glorious feeling" when we reached home and families that evening and found all well.

The tuataras came the next day as well and hearty as when I last saw them at Oakland, California. They certainly had been well cared for and there was enough raw beef poked in their box to last them for months; also a lot of sticks, lead pencils etc., which had been used by inquisitive people for the purpose of stirring them up. Letters were received from several of the baggage men who had them in charge on different runs from California to Iowa City asking if they got through all right and telling how they had been taken care of on the way.

The collections arrived safely after considerable delay at the Customs House at Des Moines. I was called upon to exhibit bills-of-lading, although it had been impossible to obtain them, there being no American Consular officer at Fiji and, by arrangements with the Union Line at Wellington, the collections were shipped as baggage and hence no bills-of-lading were forthcoming either from Fiji or New Zealand.

When I visited Des Moines to see them through the customs I was required to file a heavy bond on account of not being able to produce the bills-of-lading. The fact that the collections were the property of the State of Iowa seemed to cut no figure at all. I was told that if, after an interval of several months, I was unable to obtain the bills-of-lading, and stated why, on oath, the bonds would be released. I protested that these reasons were known to me just as well then as they would be after a lapse of months and gave them, asking if the explanation was satisfactory. The official said that it was, but that the bonds would have to be furnished just the same and an application for their release, with reasons given on oath, at the end of the required period would be necessary. Great and mysterious and beyond comprehension are the ways of customs officials in the United States!

But all these irritating delays passed at last, and the collection, including the priceless gifts from the museum at Wellington is safely stored in the museum at the State University of Iowa, where it will interest the public and be used by students for years to come.

In closing this narrative I wish to express my high appreciation of the services of my comrades, Wylie, Thomas, Stoner and Glock for their fine work in carrying out the objectives of the Expedition, and to Mrs. Stoner who so efficiently helped with the commissary department while we were at Makuluva, Fiji.

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